ENGINEERING-EDUCATION

Bulletin of the

Society for the Promotion of Engineering Education

VOL. IX LANCASTER, PA., JUNE, 1919 NO. 10

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BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

John F. Hayford, Milo S. Ketchum, F. L. Bishop, *Editor*.

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

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FRANK JOHNSON GOODNOW.

PRESIDENT, THE JOHNS HOPKINS UNIVERSITY.

President Frank Johnson Goodnow was born in Brooklyn, New York, in 1859. He entered Amherst College in 1875 and was graduated with the degree of bachelor of arts in 1879. He entered the Columbia University Law School in 1881 and obtained the degree of bachelor of laws in 1882. In the same year he was admitted to the bar of the State of New York and began the practice of his profession in the City of New York. In 1883 he was offered a position to teach administrative law in the newly established School of Political Science of Columbia University and was given a year's leave of absence to study in Europe. In the year 1883–84 he studied at the École Libre des Sciences Politiques at Paris and the University of Berlin.

President Goodnow began his teaching career at Columbia in the autumn of 1884 and remained there continuously until 1914. During that period he contributed many articles on subjects connected with administrative law and wrote a number of books on various phases of public law.

He was also a member of the commission which drafted the present charter of the City of New York and a member of President Taft's Commission on Economy and Efficiency, obtaining leave of absence from Columbia University to take up his work at Washington. He was later appointed legal adviser to the government of the Republic of China and spent nearly two years in Pekin, whence he returned to this country to accept the presidency of The Johns Hopkins University in October, 1914. Since his assumption of administrative work at the university he has continued his activity in public affairs. In 1915 he was appointed chairman of the Maryland

FRANK J. GOODNOW,

PRESIDENT, THE JOHNS HOPKINS UNIVERSITY.

Commission on Economy and Efficiency. This commission among other things drafted an amendment to the Maryland Constitution, subsequently adopted, which made provision for an executive budget and has been extensively copied by other States.

JOHN F. HAYFORD.

PRESIDENT, SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, 1918–19.

John F. Hayford, C.E., Sc.D., was born on a farm near Rouses Point, N. Y., May 19, 1868. His ancestors for several generations back were Americans engaged in farming or in mechanical pursuits. He graduated from Cornell University in June, 1889, and immediately assumed his duties with the Coast and Geodetic Survey in Washington continuing this work for seventeen years between 1889 and 1909, with an interruption of three years, 1895–98, when he was an instructor in civil engineering at Cornell University.

During the period 1898–1909, while doing the executive work incidental to the fact that he was in charge of both the field and office work of the triangulation, precise leveling, and astronomic work of the survey, he was also active in improving methods and research work. During that period the methods of primary triangulation and of precise leveling were so changed as to greatly increase the rate of progress and diminish the unit cost while maintaining the standard of accuracy at or above its former level. A new precise level and a new portable transit micrometer instrument for determining differences of longitude, which were devised under his general direction, have proved to be epoch makers. Extensive researches by him intended to determine the reasons for prevailing disturbances observed over the whole earth in the direction and intensity of gravity culminated in decided improvements in the methods of determining the shape and size of the earth and furnished decisive proof that the condition called isostasy exists. This proof shows definitely that the rocks underlying the United States to a depth of possibly as great as 75 miles have a smaller average density than the rocks under the adjacent oceans.

JOHN F. HAYFORD,

PRESIDENT, SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

JOHN F. HAYFORD.

Since 1909 Mr. Hayford has been the director of the College of Engineering at Northwestern University, which he characterizes as a new college in which the main emphasis is put on quality first.

He has been connected at various times with fixing four international boundaries, United States and Mexico, United States and Canada, United States and Alaska, and Costa Rica and Panama. He has been a member of the National Advisory Committee for Aeronautics since 1915. During the war Mr. Hayford has been in Washington about three fourths of the time on war problems as a rule connected with aeronautics.

Director Hayford first became active in the Society in 1905 and 1906 when he presented papers entitled "Opportunities for Engineers in the Government Service" and "Why not Teach about Men, the Most Difficult Tools an Engineer Uses?"

ANNOUNCEMENT AND PRELIMINARY PROGRAM OF THE 27TH ANNUAL MEETING, THE JOHNS HOPKINS UNIVERSITY, HOMEWOOD, BALTIMORE, MD.

11:30 A.M.—Meeting of the Council at Johns Hopkins Club.
2:00 P.M.—Opening Session,

President Hayford Presiding.

Address of Welcome. Frank J. Goodnow, President, The Johns Hopkins University.

Response. John F. Hayford, President of the Society.

Report of Special Committee on the report of the Joint Committee on Engineering Education. W. E. Mott, Chairman. Chairman.

The Case System for the Study of Law; What it is, and its Bearing on Engineering Education. C. F. Allen, West Roxbury, Mass.

Mental Tests for Engineering Students. Walter V. Bingham, Carnegie Institute of Technology, Pittsburgh, Pa.

Report of Committee No. 15, Civil Engineering. A. H. Fuller, Chairman.

Highway Transport Engineering. A. H. Blanchard, President, National Highway Traffic Association, New York City.

Appointment of Committees on Resolutions and Nominations.

8:00 P.M.—Annual mixer meeting at Baltimore Country Club.

THURSDAY, JUNE 26.

9:00 A.M.—Meeting of the Council.

9:30 A.M.—Second session.

Effect of the War on Engineering Education. Discussion opened by Anson Marston, The Iowa State College.

Report of Committee No. 8, Admission. E. F. Coddington, Chairman.

Report of Committee No. 10, Mathematics. L. C. Plant, Chairman.

Report of Committee No. 11-A, Physics. G. W. Stewart, Chairman.

Report of Committee No. 12, English. C. W. Park, Chairman.

The Unconscious Plagiarist. G. I. Mitchell, University of Pittsburgh.

12:00 M.—Informal luncheon for convention in Machinery Hall.

2:00 P.M.—Third session,

Military Training in Engineering Schools. Col. F. J. Morrow, Chairman, Committee on Education and Special Training of the War Department. Charles S. Howe, President, Case School of Applied Science.

Report of Committee No. 16, Mechanical Engineering. O. A. Leutwiler, Chairman.

Teaching Safety in Engineering Schools. George W. Case, University of Pittsburgh.

Report of Committee No. 17, Electrical Engineering. C. Francis Harding, Chairman.

Report of Committee No. 18, Mining Engineering. F. W. Sperr, Chairman.

Report of Committee No. 20, Standardization of Technical Nomenclature. John T. Faig, Chairman.

7:30 P.M.—Annual dinner at Baltimore Country Club.

Presidential Address: "Reflections of an S. P. E. E. President." President John F. Hayford.

FRIDAY, JUNE 27.

9:00 A.M.—Meeting of the Council.

9:30 A.M.—Fourth Session.

The Society for the Promotion of Engineering Education. A Survey of its Past and a Reconnaissance of its Future. George R. Chatburn, Past President.

The Vitalizing Principles in Education. Edward J. Kunze, Cooper Union.

Vocational Correlation. O. J. Ferguson, University of Nebraska.

Report of the Treasurer.

Report of the Secretary.

11:00 A.M.

Leave The Johns Hopkins University by street car, taking train at Camden Station at 12:00 M. for Annapolis.

1:15 P.M.—Luncheon at Carvel Hall.

Inspection of the United States Naval Academy and the Engineering Experiment Station.

6:00 P.M.—Take train for Baltimore.

8:00 P.M.—Informal smoker, location to be announced at meeting.

SATURDAY, JUNE 28.

9:00 A.M.—Meeting of the Council.

9:30 A.M.—Fifth session.

Report of Committee on Resolutions.

Report of Committee on Nominations.

Election of Officers.

Symposium on Changes in Courses. The New Course at Tufts College, Gardner C. Anthony, Tufts College.

Report of Committee No. 11-B, Chemistry. R. M. Bird, Chairman.

Report of Committee No. 13, Mechanics and Hydraulics. O. H. Basquin, Chairman.

Report of Committee No. 14, Economics. C. C. Williams, Chairman.

12:30 P.M.—Adjournment.

Meeting Place.

Mechanical and Electrical Engineering Building, The Johns Hopkins University, Homewood, Baltimore, Md.

Registration and Information.

The place of registration and general information will be in one of the rooms of the Mechanical and Electrical Engineering Building.

Recreation and Excursions.

The Local Committee has arranged a luncheon for the first meeting of the Council at the Johns Hopkins Club at 12:30 P.M., Wednesday, June 25. The annual mixer meeting will be held at the Baltimore Country Club, Wednesday evening at 8:P.M., and the annual dinner at the same place Thursday evening at 7:30 P.M. This dinner will be $3.00 per plate. Friday afternoon has been set aside for a trip to the U. S. Naval Academy and the Engineering Experiment Station. Street cars will leave the University at 11:00 A.M. in order to make connections at Camden Station with the train leaving there at 12 M. Luncheon will be served at Carvel Hall, Annapolis, at 1:15 at 75c. per person. There will be an informal smoker on Friday evening at 8:00 P.M., the location to be announced at the meeting.

Headquarters will be established at The Rennert. The rates are single rooms without bath, $1.50 to $2.50; with bath, $2.50 to $5.00, single; second person in room $1.50 additional.

Other hotels and rates are:

Southern Hotel—$3 and $4 per day, single; $5, $6 and $7 per day, double. Every room has bath.

Belvedere Hotel—$3 and $4 per day, single; $5, $6 and $7 per day, double.

The Emerson—Rooms without bath, $3.50 and $4; with bath, $4 and $4.50. Room with bath, two persons, $7 and $7.50 per day.

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A. G. Christie, *Chairman,*
J. H. Bringhurst, J. C. Smallwood,
M. W. Pullen.

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OFFICERS FOR THE 1919 MEETING.

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W. O. Wiley, *Treasurer.*
F. L. Bishop, *Secretary.*

PRELIMINARY REPORT OF SPECIAL COMMITTEE ON THE REPORT OF THE JOINT COMMITTEE ON ENGINEERING EDUCATION.

W. E. Mott, *Chairman,* Carnegie Institute of Technology; C. S. Howe, Case School of Applied Science; L. M. Hoskins, Palo Alto, Calif.; T. U. Taylor, University of Texas; F. H. Constant, Princeton University.

The members of the Special Committee appointed "to make a study" of Dr. Mann's report have been unable to hold a meeting because of their wide geographical distribution. It seems wise to indicate in advance of the Baltimore meeting what the nature of our report will be and the chairman is therefore taking the responsibility of publishing at this time what may perhaps be regarded as a preliminary or progress report. The members of the Society who have read and discussed "The Study of Engineering Education" will realize that unanimity of view regarding the same is impossible even in a committee of five.

The purpose of presenting the report in the form of a set of resolutions is to concentrate discussion upon certain definite questions raised by Dr. Mann. It is not assumed that other important phases of the "study" should not be discussed by the Society and doubtless individual members will propose some of these other questions for debate.

Again, the six points raised are those which could perhaps be adopted in any given institution with the least amount of rearrangement of administrative and teaching machinery and may therefore be discussed on their intrinsic merits, or the reverse. We are very apt to oppose a new pedagogic proposition because we feel it will not work under our own particular local conditions.

If the sub-committee report serves to concentrate discussion and hasten action by the Society upon at least some of the

vital questions raised by Dr. Mann its purpose will have been attained.

The *form* of the following report is agreed to by a majority of the sub-committee and the six items are also subscribed to by a majority, though not always by the same individuals.

It must, therefore, be explicitly stated, and understood, that the individual members of the committee are not committed to vote affirmatively upon all six items of the report, or even that all hold the view that each of the points raised should be discussed as presented.

REPORT OF SPECIAL COMMITTEE "APPOINTED TO MAKE A STUDY OF THE REPORT OF THE JOINT COMMITTEE ON ENGINEERING EDUCATION, AS PRESENTED BY DR. C. R. MANN, AND REPORT TO THE SOCIETY."

WHEREAS, The experience of engineering educational institutions, especially during the period of the war, indicates that many of the practices now adopted in the training of engineers are susceptible of modification and improvement, and,

WHEREAS, The Society for the Promotion of Engineering Education should do everything possible to advance the cause of engineering education by the establishment of standards when necessary and by active coöperation with schools, colleges and universities in carrying forward educational research and experimentation, and,

WHEREAS, "The Study of Engineering Education," prepared by Dr. Charles R. Mann, and presented before this Society by the Joint Committee on Engineering Education, has set forth the main points at issue in such plain and forceful language that engineers and educators alike have given this report most careful consideration, therefore, be it

Resolved, 1. That this Society, through its Committee on Admission, or otherwise, recommend that psychological "objective," "trade" or other similar tests be given to all students after admission to engineering courses of study and that the ratings thus obtained be compared with their subsequent scholastic progress.

2. That this Society should recommend the establishment and adoption of standards, or tests, whereby the mental growth of students and their power to assimilate and coördinate knowledge may be evaluated in terms easily recognizable by both educators and employers, such standards to be applied during and at the end of the course of study.

3. That schedules of study for engineering students should call for not more than forty-eight (48) work hours per week (including recitation, laboratory, field work and home preparation), this time to be divided among not more than five (5) subjects which require preparation outside of class exercise.

4. That all engineering students should be required to pursue courses which will prepare them for administrative duties and for responsible and effective citizenship. These courses should involve constant training in the use of English, both written and oral.

5. That a committee be appointed, to study and report to the Society, the most desirable method or methods, of carrying on shop work for students pursuing engineering courses, so that such shop work shall motivate as many of the courses of study as possible.

6. That the Society should coöperate with the national and other engineering societies, with a view to establishing a classification of the work, or positions, including specifications as to necessary preparation and qualifications, into which our engineering graduates enter, so that undergraduate students would thus have a clearer understanding of the work for which they are preparing themselves and instructors have before them a constant reminder of the main purpose of their teaching work.

DEPARTMENTAL AUTONOMY.

BY W. H. RAYNER,

Associate in Civil Engineering, University of Illinois.

In any complex undertaking which involves the efforts of many individuals we acknowledge at once the value of sympathetic coöperation made effective through coördination in reaching a common goal. Our experience in conducting the war through many war boards, bureaus, and commissions has given a new meaning to the word "coördination." In so vast an enterprise with so many sources of authority it is small wonder that confusion and waste accompanied our notable achievements. We can easily appreciate the point of view of those who sought to coördinate the efforts of all departments by urging the President to centralize authority and responsibility in one supreme war board.

In our educational institutions it so happens that we have in each university many departments which have grown up parallel to and quite separate from each other, and on account of this condition many persons believe the work of the schools is very seriously injured. In fact, the Joint Committee on Engineering Education of the National Engineering Societies has made particular mention of this subject in their introduction to Professor C. R. Mann's report on "A Study of Engineering Education."

The vital question seems to be whether or not, and how far, a given department should yield its control over courses in compliance with a policy of coördination with other departments, and it will be our purpose in the following paragraphs to present some of the arguments both for and against a change in the status quo.

It will be helpful first to quote the brief description given by Professor Mann of the two types of organization in our engineering schools which exemplify the conditions under dis-

cussion. The two plans are designated as "autonomous-department" and the "Cincinnati" plans, and are described briefly as follows, pp. 29, 30: under the former plan, "the choice of subject matter, texts, and methods of instruction in each subject is left entirely to the department concerned. For example, if three hours a week is assigned by the faculty to English, the Department of English may use the time in any way it likes. Each department is treated as an expert in its own line, and this departmental autonomy is carefully preserved by common consent."

"At Cincinnati the engineering school has its own department of English, mathematics and foreign languages; and the departments of physics and chemistry, though organized under the faculty of liberal arts, are represented in the engineering faculty by the instructors who teach the engineers. The faculty thus constituted meets every Saturday morning for a systematic study of its educational problems." "A syllabus stating the objects, the methods, the subject-matter, and the mechanism of the school as a whole was prepared by the dean and discussed at length by the faculty. After many changes and amendments the syllabus was finally adopted as an adequate expression of the basic conceptions toward which the school as a whole is working." Additional features are mentioned by the report which illustrate the completeness with which coördination applies to all the departments in the university.

The main arguments in favor of the autonomous-department plan are three:

First, this type has the advantage of administrative feasibility; or stated negatively, it would be very difficult, if not impossible, in some cases, to provide the separate sections necessary to differentiate chemistry, for example, to meet the needs of each of several engineering departments, architectural, civil, mining, mechanical, etc.

The second argument favoring this type of organization is the idea that only a broad foundation of fundamental principles is adequate to equip our students to cope successfully

with any situation that may arise. Moreover, each department, *e. g.*, the chemistry department, is deemed to be the only competent authority to say what those principles in chemistry are and how they shall be presented; therefore that department logically should organize the courses to be given all beginning students in chemistry.

The third argument may be stated somewhat as follows: thorough preparation is needed in certain fundamentals not only as providing a thoroughgoing basic preparation, but for the contribution they make to breadth of view, to a disciplined mind and to general training. This argument states that such subjects as mathematics, chemistry, physics, mechanics, etc., are peculiarly pregnant with possibility for developing such qualities as observation, attention, concentration, logical reasoning, etc., which go to make up general intelligence in the field of engineering. These subjects are the especially adapted apparatus by which intellectual muscle is developed and mental power trained.

These arguments then lead to the conclusion that coördination between departments, at least so far as say freshman and sophomore subjects are concerned, is bad and autonomy should be preserved.

The arguments supporting more complete coördination may be stated best perhaps in refutation of the arguments given above.

First, administrative difficulties may be great, but, where possible, they are to be removed rather than feared.

Second, the proponents of coördination would ask regarding the need for a broad foundation, just what is meant by this argument. In engineering construction while the matter of an adequate foundation is exceedingly important yet great care is exercised that it shall not be broader than the superstructure will require. Anything more than that is considered to be sheer waste of energy and materials. So it becomes a matter of adjustment and careful consideration as to just what the dimensions and needs of the foundation shall be and a department may claim on this argument that it is the more

competent to prescribe the content and extent of the foundation courses for its own students.

Third, as regards the idea that certain subjects are peculiarly beneficial in training the mind, the answer would be made that here is a fundamental issue which requires some analysis of the nature of education itself. The notion that part of the function of education is to discipline the mind, to develop intellectual powers, or has for its aim the "harmonious development of all the powers," is based on one of two theories, (*a*) faculty psychology, or (*b*) transfer of training.

The former theory states that the mind is composed of rudimentary or undeveloped faculties, such as memory, attention, concentration, logical reasoning, etc., and that it is the duty of education to get at the business of training these faculties for life's endeavors. This theory has now been abandoned by all psychologists and is not worthy of further notice here.

The conception of transfer of training states that certain qualities of mind developed in the study of one subject will carry over into other activities. Thus the study of mathematics will develop powers of abstract thinking, logical reasoning, etc., etc., and these qualities will carry over and function in engineering, law, medicine, or economics. This idea has many advocates, but they all agree that the amount of transfer is very much more limited than is generally supposed. So Thorndike concludes "that a change in one function alters any other only in so far as the two functions have as factors identical elements." *E. g.*, improvement in addition will improve arithmetic because there are identical elements in both.

One of the most recent and authoritative statements on this subject may be fairly interpreted by the two following quotations:*

"An appreciation of mathematical or syllogistic cogency,

* Bode, B. H., *School and Society*, January 11, 1919.

for example, may leave other forms of reasoning untouched; devotion to truth in the laboratory is no guarantee of open-mindedness and impartiality of judgment in other fields, and the punctilio of card-playing and duelling warrants no inference with regard to conduct in general."

"Taken as a mechanical or automatic transmission, there is no transfer of training; taken as a conscious activity, transfer of training becomes synonymous with intelligent behavior." This means that we may not rest on the supposition that every kind of training is good for the mind in general, but that education is effective in so far as it provides rich and adequate concepts regarding the factors with which the student must deal when he meets a new situation, and mental training afforded by the study of any given subject is effective in other fields only in so far as these concepts have been developed in pursuance of definite aims.

Or if we take an example from the development of an athlete we may perhaps find the analogy useful. If there is no particular end in view, if our athlete is not training for any particular activity it will not make much difference what apparatus he uses; dumb bells, Indian-clubs, chest weights, parallel-bars, all will be equally good. But if he is training to be a pole-vaulter, a runner or a base-ball player he will not waste much time or effort on gymnasium apparatus in the "harmonious development of all his powers." His coaches know pretty definitely what muscles and coördinations need training and these are the ones he cultivates, and this development takes place mainly in doing the very thing in which he hopes to excel.

In fact, there is known to be such a thing as interference in training. Suppose a man learns one keyboard on a typewriter and then changes to another. He is worse off than had he never seen a typewriter. And also, the development of certain muscles in the training of an athlete are consciously avoided because of their interference with the best development of the requisite powers for the end in view.

It is this principle which may account for the complaint

that the college trained man is egregiously lacking in common sense. In a new situation he is helpless unless he can find a text-book formula to fit the case. In other words, it is possible that our educational process may distinctly injure or interfere with the proper development of valuable native ability.

If these notions about transfer have any validity here, it means that a great deal of the alleged value of certain subjects to provide general training, discipline, etc., simply does not exist.

On the positive side it means that it is simply good sense to educate our students as definitely as possible following clearly defined aims at every step. The resulting economy of time and effort would provide opportunity for far more intensive, extensive and thoroughgoing development in the chosen field; or more time and opportunity would be provided to work out the complex connections which the student's field of endeavor has with life. Thus the real meaning and significance of a man's vocation to the community and nation might be made more evident, and to that extent he would be a more intelligent and cultured man.

From these arguments, then, each department is the body of experts, whose proper function it should be to prescribe or at least approve the content and aims of courses to be provided for its students.

REPORT OF COMMITTEE NO. 13, MECHANICS AND HYDRAULICS.

Topic: Main Objectives in Teaching These Subjects.

O. H. Basquin, *Chairman,* Northwestern University; J. E. Boyd, The Ohio State University; C. H. Burnside, Columbia University; H. F. Moore, University of Illinois; C. I. Corp, University of Wisconsin.

1. The courses to which this report particularly relates are those of mechanics, strength of materials, and hydraulics; portions of the report may be considered to be of more general application. Preceding mechanics, the student has had an introduction to this subject as a part of general physics; he has had a course in calculus, or takes that study along with mechanics.

2. In each of the three courses considered, one of the main objectives is to give the student a working knowledge of fundamental facts and principles. An engineer needs a working knowledge of essentials rather than a superficial knowledge of a wide range of information. One who is not confident of the essential accuracy of his knowledge does not readily gain the confidence of others, and rarely maintains his own self-respect.

3. The course in mechanics makes extended use of facts and principles which the student should have acquired in physics, calculus, geometry, algebra, and arithmetic. A first duty of the instructor in mechanics is to put the essential parts of these prerequisite subjects into working order; and this instructor should not look upon his task as that of doing another man's work. One can rarely secure thorough knowledge of any fact on first meeting it; the early courses cannot give the wealth of illustration and the new points of view that are available in later courses; and repetition at intervals is a particularly efficient method of learning.

4. Similar suggestions might be made with respect to strength of materials and to hydraulics; in fact, with respect

to almost any course of an engineering program. The objective is to put the essential facts and principles into such form that they can be used by the student with readiness, accuracy, and certainty.

5. The student must become proficient in the solution of problems. Under proper circumstances, it is believed that some of this problem work should be done under supervision, for the purpose of giving the student a start in logical thinking and in orderly, accurate, and economical methods. This suggestion is based upon the principle that it is easier to start a right habit at the beginning than to correct a wrong one. The chief danger in adopting this suggestion is that the instructor may not give the proper kind of supervision: he must not be dictatorial but must develop initiative; his work is to make the student do his own thinking in a proper manner—not to think for the student; when the student has acquired this ability he needs no further supervision.

6. Mechanics is an experimental science; experimental work should accompany each course under consideration. A blind person cannot understand the theory of painting because he cannot experience the sensations of color. In a similar way, a student cannot comprehend mechanics unless he can experiment, because it is only through experiment that he obtains the fundamental concepts upon which the subject is based. The student needs experiments to illustrate in a concrete way some of the important derived facts that are developed in theory, to show their degree of accuracy, and to point out their limitations. In this connection it is to be noted that such experiments, to be most useful, should be so correlated with the class instruction that these concepts and illustrations will be given to the student by the laboratory work at appropriate stages in the development of theory in the class room.

7. The successful engineer is an accurate observer and he draws conclusions from data directly obtained from observed facts. Laboratory work is particularly useful in developing habits of observation on the part of the student. A text-book

problem gives a more or less definite key to its solution through its selection of data: this is not the case with problems that arise in the laboratory; here the student has a chance to apply his knowledge to facts that he obtains through his own selection and observation. The instructor who deprives the student of this experience by giving too minute instructions, denies him an excellent opportunity to develop that resourcefulness and straight-forward thinking, which an engineer must have when facing practical problems.

8. Since an act of observation is not complete until the student has recorded and explained what he has observed, the report is an essential part of laboratory work. It serves to fix the observed facts in the student's mind in an orderly sequence and in an emphatic manner, while it enforces thought upon unselected data. While the report should be in good form, the student should be encouraged to limit its contents to essential matter.

9. Many of the principles of engineering are based upon assumptions, while approximations are often made in analyses. Since the student should be taught to think logically, it is of prime importance that the instructor make a sharp distinction between fact and assumption, between strict analysis and approximation. In reaching conclusions, analyses should be used whose refinement is appropriate to the data obtainable, and the limitations of the conclusions should be recognized. These suggestions relate to the development of intellectual integrity; it is not suggested that these matters be given such undue prominence as to confuse the student, but it is highly important that the instructor appreciate them and make them clear to the student on appropriate occasions.

10. The engineer needs a fluent command of good and forceful English. This is largely a matter of habit, and its development can be brought about most effectively by the coöperation of all instructors to this end. Every student should acquire habits of punctuality in the prompt completion of every duty, of numerical accuracy of acceptable grade, of the presentation of work in good form, and of economical methods of

study. Such habits improve the efficiency of instruction and form the beginning of character development. All instructors should coöperate in their formation.

11. Every instructor should regard it as his duty to make his course interesting—not easy or amusing. A course is interesting to a student if he feels that the value that he is able to get from it is large in comparison with the effort that it costs. Interest makes the student put forth his best efforts with pleasure, it makes him observant of cases that arise in his daily life where his knowledge gives new insight, and it tends to make him continue to be a student of the subject after he has left the instructor's guidance. With this in view, the instructor should specialize in making explanations in simple language, using concrete illustrations that will be appreciated by every student. Interest may be stimulated by letting the student know in advance how he will use a principle about to be studied, by allowing the student to do a part of the thinking in the development of a principle, and by so arranging the assignments that the student will feel that he has made some definite worth-while acquisition from each assignment.

12. The instructor should seek to develop in the student such mental attitudes as will assist instruction and be of permanent value to the student. The spirit of coöperation should characterize intercourse between instructor and student. The group system in laboratory work and in field work may be used to develop both coöperation and leadership. Uniformly thorough work coupled with encouragement of the student's initiative will give him confidence in his knowledge and in his ability to apply it. Insistence upon the full performance of every assignment, accompanied with extreme care on the part of the instructor to make appropriate assignments, will tend to develop in the student the feeling that he can and must accomplish every duty set before him. The instructor should understand the relations which an engineer should sustain to the community, to the state, and to civilization, and, when the occasion warrants, he should make

his students feel the necessity of assuming these obligations.

13. It is believed that much good may result if the instructor gives due consideration to the following quotation from Thorndike's "Principles of Teaching": "The efficiency of any profession depends in large measure upon the degree to which it becomes scientific. The profession of teaching will improve (1) in proportion as its members direct their daily work by the scientific spirit and methods, that is by honest, open-minded consideration of facts, by freedom from superstitions, fancies or unverified guesses, and (2) in proportion as the leaders in education direct their choices of methods by the results of scientific investigations rather than by general opinion."

SUMMARY.

I. *Objectives of Knowledge.*

1. *Mechanics.*—Thorough training in fundamental facts and principles, enabling the student to recognize the mechanical principles and the mathematical treatment appropriate for simple problems for which he takes his own data.

2. *Strength of Materials.*—Working knowledge of the common theory of elastic action, and its application to the simple members of structures and of machines, paying attention to assumptions in theory and to limitations when conclusions are applied to actual materials.

3. *Hydraulics.*—Thorough understanding of the principles of hydrostatics and of fluid motion, with simple applications so arranged as to bring out the relations between theory and experiment.

Each course should give a thorough drill in all ground covered, using oral recitations, blackboard demonstrations, informal written quizzes, problems, and laboratory work.

II. *Objectives of Habit.*

Certain general habits on the part of a student should be encouraged by all his instructors; among these may be mentioned (1) intellectual integrity, (2) good English, (3) eco-

nomical methods of study, (4) punctuality, (5) completion of assignments, (6) numerical accuracy, and (7) presentation of work in good form.

III. *Objectives of Attitude.*

For the purpose of making the student's work more efficient and to make him a better man, every instructor should seek to develop in him certain mental attitudes, such as (1) interest in his work, (2) coöperation with his associates, (3) leadership, (4) self-confidence, and (5) duty.

It is believed that the instructor should be a student of the teaching process.

MACHINE WORK AT THE OHIO STATE UNIVERSITY.

BY W. A. KNIGHT,

Associate Professor Machine Shop Practice.

It is the purpose here to give, somewhat in detail, the method of conducting machine work at The Ohio State University. The system has been in operation now five years, long enough for the glamor incident to trying out a new scheme to wear off, and to view the work in the light of practical experience. It is believed that the plan has merit and can readily be adapted to most college shops. Naturally, all of the questions that may arise in connection with the operation of the plan, can not be answered within the scope of an article like this, but sufficient detail will be given to enable one interested to form a fairly correct estimate of its soundness and practicability.

Students in electrical and mechanical engineering are required to take six hours of machine work per week for a school year. Of this time five hours per week are spent in the shop and one hour per week in the class room for lectures and recitations. The year is divided into the usual two semesters, the first of which is devoted to what is scheduled as elementary machine work, and the second to advanced machine work.

First Semester's Work.

During the first semester the student, after a couple of preliminary exercises on straight and taper turning, makes complete a small emery wheel stand. The making of this stand furnishes exercises in the fundamental operation of turning, boring, reaming, threading, chuck and face plate work, drilling, tapping, babbiting, scraping in bearings, and some little planer and milling machine work.

While the work is not on a productive basis in the sense in which a product is regularly placed on the market, yet it is, in the sense that every piece is made with the definite object in view of using it in the finished machine; and, further, the product is complete in itself and has marketable value when finished. Each student finishes his own grinder, and although certain standards are maintained, the work is in no sense in-

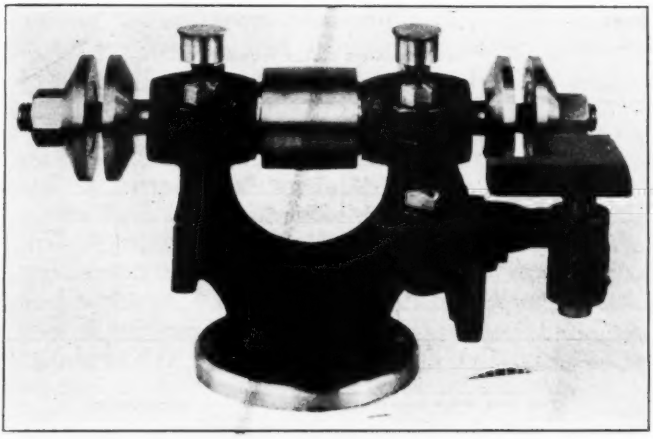


FIG. 1. Grinder of First Semester's Work.

terchangeable. The work is individualistic. The methods followed are in the nature of machine building rather than manufacturing. However, attention is here directed to the fact that the making of a complete piece of apparatus such as the grinder stand, appeals strongly to the student's constructive desires. He has an object in view and can see that object develop as his work progresses.

The work of the class room parallels that of the shop. A more complete consideration can here be given of the various machines, tools, operations and methods than can be given in the shop. Having completed this semester's work, the stu-

dent is more or less familiar with the machines in the shop, the small tools, tool room system, and has been introduced to many of the fundamental operations of machine work. He is then in position to take up the more advanced work.

Second Semester's Work.

In this the class works as an organization. The work is run through in quantity and is interchangeable. Finished

Form 1239

FOREMAN'S DAILY REPORT DIV. A

CHECK NO. _____ NAME _____ DATE _____

WORKMAN	MACH. NO.	DR'W'G NO.	OPERATION	PIECES FIN'H'D	PIECES O. K'D
B. Smith	32	301	Cut Key ways		
A. Jackson	9	300	Bore and Ream		
T. Roberts	17	294	Bore		
B. Hunt	14	298	Rough Turn		
H. Bucher	15	301	Turn End Face		
B. Carson	35	301	Cut Teeth		

REMARKS:

THE OHIO STATE UNIVERSITY, INDUSTRIAL ARTS DEPARTMENT

FIG. 2. Issued in this Form as Instructions to Foreman.

parts are inspected and pass into the stock room to be requisitioned out for assembly toward the end of the semester. An operation sheet is furnished the student, giving the tools, speeds and feeds and a standard time for each operation.

The organization is very simple. A class is divided into divisions of five to seven men each. These are lettered A, B, C, D, . . ., and each is in charge of a division foreman selected from members of the class. There is also an accountant who keeps the records. Ordinarily, the divisions are productive; that is to say, they work on the regular product of the shop, but practically with every class there is a maintenance division organized. The duties of this division are to

make repairs for the upkeep of the equipment, make new tools, do development work and to take care of other little jobs that come along.

The foremen serve a period of four weeks. At the end of this period the standing of the class is determined, the foremen are retired to the position of workmen and their places filled by members of the class who have made the best grade for the four weeks' period. This is repeated at the end of another four weeks and so on until the end of the semester. A student, however, does not hold the position the second time, the selection being made from those who have not served in that capacity.

It is the duty of a division foreman to assign work, see that the proper speeds and feeds are used, give advice and assistance to his men, and, in general, perform the duties of a regular foreman. He should keep in close touch with the instructor, aiming to keep somewhat ahead of his men on the requirements of the work. The foremen also act as inspectors, each inspecting the work of his own division. When a piece is inspected it is marked with chalk, either O.K. (accepted) or N.G. (no good), together with the foreman's check number. A daily report is filed by the foreman showing the number of pieces finished and number O.K.'d by each of their workmen. (See Fig. 3.)

The accountant acts also as stock room keeper. The stock is placed in tote boxes ready to be handed out. The first duty of the accountant is to hand out these boxes. He then takes up the reports of the previous class and proceeds to enter them each in its appropriate place. He next adjusts the production board to correspond with the increase of production. Having finished this, he makes tests with schleroscope on two samples of hardened steel, recording his observations on blanks furnished for that purpose. There is then a set of ten defective castings to be inspected and reported on. This, together with taking in the boxes at the end of the period, finishes his work. The idea of the tests and inspection is to give the student something to do that will make his time in

the stock room worth while. Members of the class serve in rotation as accountant, so that each man takes part in keeping the records which are at all times open to inspection. For this period as accountant the student is allowed *straight time.*

The managerial functions are performed entirely by the in-

Form 1229

FOREMAN'S DAILY REPORT Div. A

Check No. 12 Name J. C. Wilson Date 10/17/18

Workman	Mach. No.	Dr'w'g No.	Operation	Pieces Fin'h'd	Pieces O. K'd
3. Smith	32	301	Cut keyways	12	12
4. Jackson	9	300	Bore & Ream	4	3
7. Roberts	17	294	Bore	1	1
8. Hunt	14	298	Rough Turn	8	6
19. Bucher	15	301	Turn & Face	2	1
23. Carson	35	301	Cut teeth	2	2

Remarks: Roberts delayed 30 minutes on account of broken belt

The Ohio State University, Industrial Arts Department

FIG. 3. Comes Back in this Form as Foreman's Report.

structor, for the purpose is to teach shop practice rather than shop management. The instructor must do the planning, keep track of production, know before a class enters where every man is to be placed, the work he is to do and that the material is ready. His orders are, however, carried out by the division foremen.

OPERATING MECHANISM.

One of the most important items in this connection is the foremen's daily report form. This is used by the instructor in issuing orders to the foremen. As before mentioned the instructor "places" the class, that is, determines beforehand where and on what each member is to work. He writes in on the form the name, check number, machine number, drawing number and operation for each student. This is then

attached to a 3×5 in. production order card which gives the number of pieces to be gotten out, and placed in a suitable rack accessible to the foremen. At the end of the work period a foreman has but to mark in the number of pieces finished and pieces O.K.'d, sign his name and turn the slip in as his report. This form, then, as shown in Figs. 2 and 3, goes out

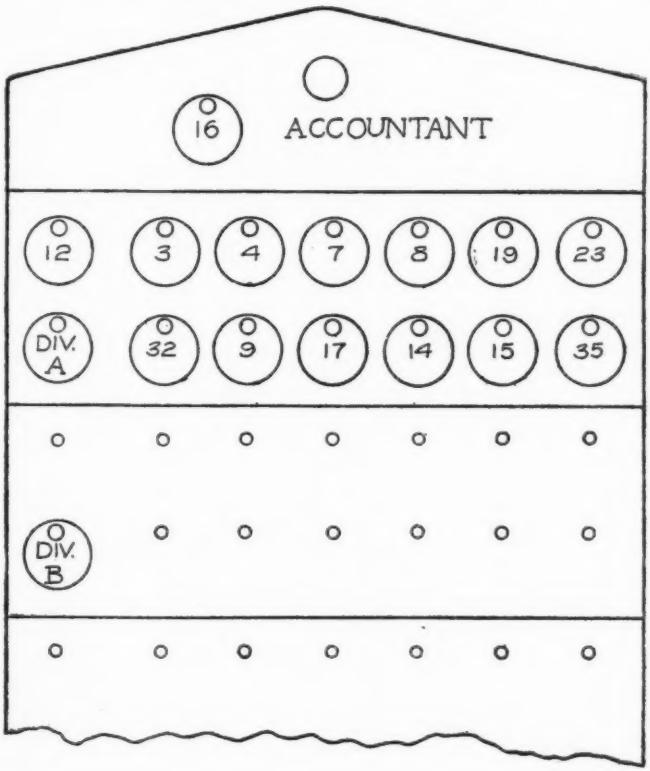
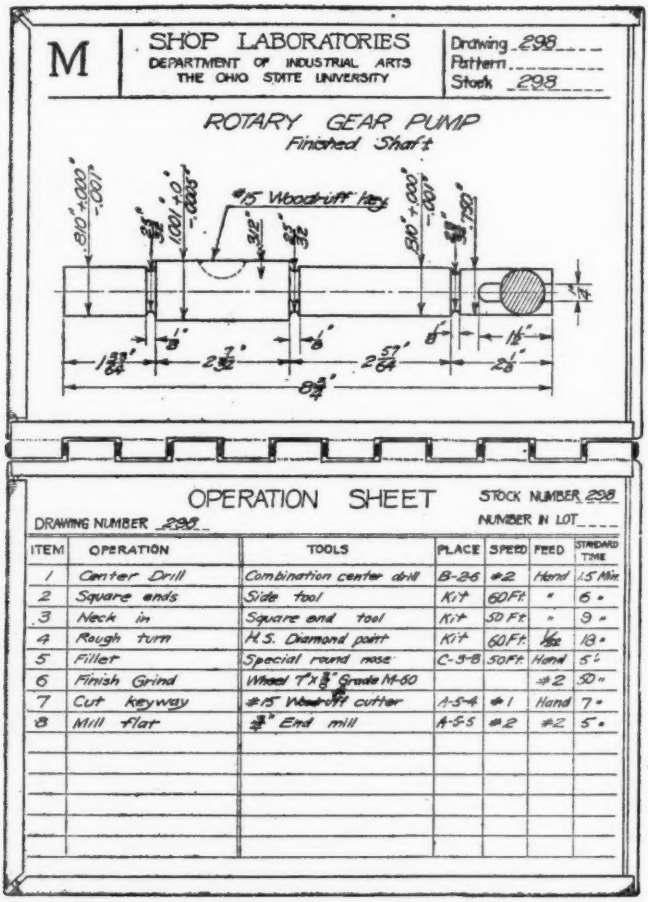


Fig. 4. CHECK BOARD

FIG. 4. Check Board.

as orders to the foremen and comes back as a report of the work.



M

SHOP LABORATORIES
DEPARTMENT OF INDUSTRIAL ARTS
THE OHIO STATE UNIVERSITY

Drawing 298
Pattern
Stock 298

ROTARY GEAR PUMP
Finished Shaft

#15 Woodruff key

OPERATION SHEET

STOCK NUMBER 298
NUMBER IN LOT

DRAWING NUMBER 298

ITEM	OPERATION	TOOLS	PLACE	SPEED	FEED	STANDARD TIME
1	Center Drill	Combination center drill	B-26	#2	Hand	1.5 Min
2	Square ends	Side tool	Kit	60 Ft.	"	6 "
3	Neck in	Square end tool	Kit	50 Ft.	"	9 "
4	Rough turn	H.S. Diamond point	Kit	60 Ft.	1/32	18 "
5	Fillet	Special round nose	C-5-B	50 Ft.	Hand	5'
6	Finish Grind	Wheel 7"x 3/4" Grade M-80			#2	50 "
7	Cut keyway	#15 Woodruff cutter	A-5-4	#1	Hand	7 "
8	Mill flat	3/4" End mill	A-5-5	#2	#2	5' "

Fig 5. DRAWING AND OPERATION SHEET.

FIG. 5. Drawing and Operation Sheet.

The check board shown in Fig. 4 is also used in connection with the placing of a class. The board is divided horizontally into five spaces. Each space has room for two rows of checks and represents one division of the class. A vertical line separates the foremen from the workmen. Check numbers of the students are placed on the upper row while the lower carries the machine numbers. The student is to work on the machine, the number of which is immediately beneath his own check number. The first upper check to the left indicates the foreman of the division. As the board is now arranged in Fig. 4 the student whose check number is 12 is foreman of Division A. Numbers 3, 4, 7, 8, 19 and 23 are his men. Number 3 is to work on machine 32, number 4 on 9, and so on. To avoid confusion in handling, the checks representing students are of aluminum, while those representing machines are of brass. The arrangement of checks on the board must, of course, correspond with the orders issued to the foremen. There is also placed at the top of the board a single check to indicate which student shall act as accountant.

An operation sheet is issued with a drawing. This gives the sequence of operations, speeds, feeds, and a standard time for each operation. A sample drawing and operation sheet are shown in Fig. 5. These are inserted in a backing of galvanized iron, two pieces being hinged together like the covers of a book. The inside edges are turned over and so made that the drawing can be slipped in from the end. A piece of clear celluloid $\frac{1}{64}$ in. thick is inserted over the drawing, and also the operation sheet, to serve as a protection. This makes a flexible arrangement, as an operation sheet can be changed without disturbing the drawing, and yet they can be handled as one unit.

A production board such as shown in Fig. 6 is used. This shows the number of pieces finished, number spoiled and number available for the next operation. It is simply a rectangular board divided into squares into which different colored plugs may be inserted. Provision is made for suitable headings along the left side. Brown plugs are used to indi-

cate good pieces, and yellow the spoiled pieces. When a report comes in, the yellow plugs are moved along to make room for good piece plugs and if there is any spoiled work it is tallied up by the insertion of additional yellow plugs.

While this board shows at a glance the state of production

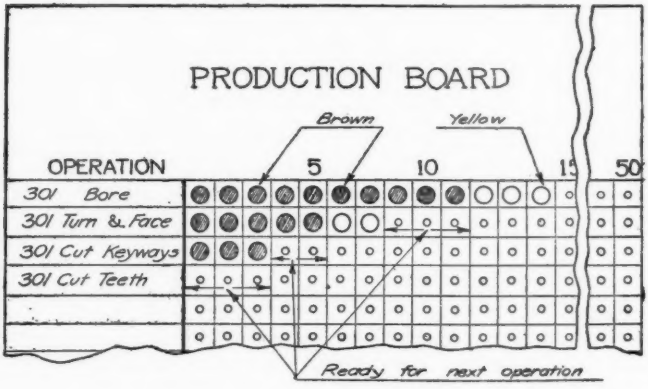


Fig. 6 PRODUCTION BOARD

FIG. 6. Production Board.

and jobs available for the next operation, it is not of much real service to the instructor in placing a class for the reason that it is always one work period behind the real shop condition. It does, however, serve a very useful purpose in bringing before the student the general character and use of such boards.

A more practical scheme for our purpose is the Finished Stock Rack. This is a section of steel shelving 12 ft. long by 6½ ft. high by 15 ins. wide, divided into compartments suitable for the work. There is a separate compartment for each operation. Take, for instance, finishing gears. The first operation is boring, (2) turning, (3) cutting keyway, (4) cutting teeth. All of the bored gears are placed in one compartment of the rack, those bored and turned in the next

adjoining, and so on, beginning at one end of the rack and working toward the other. As soon as a class turns in its tote boxes the finished pieces are taken out and placed in the rack. A brief inspection then shows how many pieces are ready for the next operation.

Operation, Grading, Records.

On entering the shop no student knows where or on what he is to work. He first consults the check board which is placed adjacent to the tool room window. A glance at this tells him on which machine he is to work. He has his tool kit issued from the tool room and goes to his machine. Meanwhile, the foreman takes his orders from the rack, proceeds to his men and gives each his drawing number and operation. The student must then get his drawing and stock and is ready to go to work. It matters not whether the foremen know the men as they can be located by the machine numbers which are so placed as to be visible from either side of the shop. Some foremen adopted the plan of getting in a little ahead of the class, writing each man's drawing number and operation on a slip of paper and leaving it at the machine. In this way the student had the desired information as soon as his machine was reached. Not a bad scheme.

A student performs a single operation for an allotted period of time. This is usually a 2-, 3- or 5-hour period. If the operation is, say, grinding shafts, which is a 50-minute job, the period would be 5 hours and the student would finish as many shafts as he could in that time. On a short time operation, like squaring ends, for which the standard time is 6 minutes, the period would be 2 hours or even less. Since we have a 2-hour work period one day (1 hour out for lecture) and 3 the next, these are the natural intervals between shifting from one operation to another. Production could be increased and spoiled work diminished by increasing the time between shifts. However, it is desired to give the student as many different operations as possible and not have him repeat

until the work becomes monotonous. A maximum of 5 hours has been found to be sufficient for the more difficult operations, while 2 to 3 hours serve the purpose well for the more simple.

The student's shop grade is based entirely on his efficiency, this being the ratio of the time it takes him to complete an operation to the standard time for that operation. He gets no credit for spoiled work. No allowance is made for getting in, getting out, set up or time that a class may be called up for instruction. All of this has been taken into account in setting standard time. Consider again the grinding of shafts —a 50-minute operation. In the 5-hour period a student should finish 6 shafts and have them pass inspection in order

Check No. 22 Name C.T. Baker Course 121 Semester 1-18

Date	Mach.	Drwg.	Operation	Daily Time	Pieces Fin.	Pieces O.K'd	Credit	Grade
9/22	—	—	Present	3	—	—	180	
9/23	14	300	Bore and Ream	3	4	3	120	
9/29	32	296	Plane	2	1	1	36	
9/30	32	296	Plane	3	3	3	108	
10/6	16	301	Turn and Face	2	1	0	0	
10/7	16	301	Turn and Face	3	2	2	160	
10/13	8	298	Mark in	2	12	11	99	
10/14	9	298	Rough turn	3	7	7	126	
			Working Time	1260	min		829	65 9/10

Fig. 7 STUDENT'S RECORD SHEET. SIZE 8½ x 11.

FIG. 7. Student's Record Sheet. Size 8½ × 11 inches

to make a grade of 100 per cent. If he finished but 3 or finished 5 and 2 were rejected, his grade would be 50. However, the grades are not figured for each 2- to 5-hour period,

but for a period of 4 weeks, which greatly simplifies the clerical work and keeping of records.

A complete record of the student's work is kept on the form shown in Fig. 7. The first entry shows that C. T. Baker was present the first day. This period is given over to an explanation of the system and a couple of demonstrations. If present, the student is allowed full time of 180 minutes and this is entered in the credit column. The next day he was on

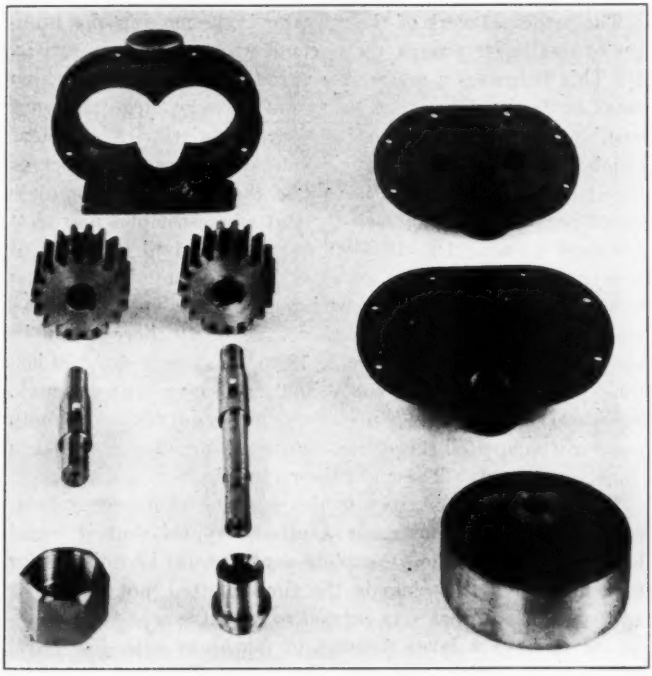


FIG. 8. Parts of Gear Pumps.

machine 14, drawing 300, operation boring, and the record shows that he finished 4 and had 3 accepted. The standard

time for this operation is 40 minutes, hence 3 times 40, or 120, is carried over into the credit column. At the end of 4 weeks this column is added up and divided by 1,200, the number of minutes he should have worked, and his grade thus obtained. It makes no difference whether a student works full time or not, the divisor is the same for every member of the class. Thus the effect of lost time through getting in late or absences and spoiled work is automatically to lower the student's grade.

The principal work of the semester is the making of a number of small gear pumps, the parts of which are shown in Fig. 8. This furnishes a reasonable variety of work, all of which must be fairly accurate. There are no very large nor very small parts and few special tools are required. A sufficient number are run through to provide one for each member of the class. Then, toward the end of the semester, a complete set of parts is issued to each student who assembles and tests his own pump. In addition to the required number of pumps, the work of the semester includes standard tension test bars, brass ink wells, screw jacks, hex nuts and cap screws made on a turret lathe. With a class of 40 there would be about 60 test bars, 40 ink wells, 12 to 15 screw jacks, 100 hex nuts (sides milled) and 200 to 300 cap screws run through. Some work of this kind is necessary, for as operation on pump parts are completed there must be something on which to keep the class at work. These are shown in Fig. 9.

Much thought was given to the selection of a proper exercise. The gas engine made a strong appeal, but it could hardly be seen that one complete engine could be finished for each member of the class in the time allotted, not unless jig and special tool work was carried to an extreme. It was preferred to have a large number of machines with few parts rather than a few machines with a large number of parts. Due consideration was also given to providing the foundry with a suitable class of work. No doubt, however, there are numerous other machines that would serve the purpose well.

In setting standard time no previous records of the time of

students were made use of. The cutting time was in every case calculated for such cuts and feeds as the work or our equipment warranted and then allowances were made for getting started, handling, measuring and time cut for instruc-

FIG. 9. Other Products made in Quantity.

tion. Working individually, the average time of a 1⅝ in. screw jack was 28 hours. Run through in lots of 12 to 15 the standard time is now 8 hr. 20 min. The time on the ink well was 8 hr. It is now 1 hr. 50 min.

This system is workable—it has the elements of modern shop practice, *i. e.*, organization, interchangeable parts, work limits, inspection, standard time and progress reports. The

student is brought into contact with these features in addition to his regular practice in the handling of machine tools. He must run his machine at the given speeds and feeds and receive proper instruction or he can not make anywhere near standard time. There is no puttering along taking two or three cuts where one will do. The cutting tools must be of correct form and the equipment must be kept in good condition. This method does not provide as many different operations for the student as when he works individually, but he obtains a more thorough knowledge of the ones he does get. The length of time on one operation is not such as to lead to monotony, but is sufficient for the student to gain confidence in himself and begin to learn what the output of a tool should be. The student is "on the job" every minute of the time.

On the other hand, there is less opportunity for the student to exercise his individual judgment. There is much additional work required of the instructors both in the way of preparation and attention while the class is in. No instruction sheets other than the operation sheet are furnished. The student has no time to stop and analyze instruction sheets. He must be shown or instructed in the proper way to do the job.

Records show that for the second 4-weeks period there is an average gain of 15 per cent. in the standing of a class. The gain is 9 per cent. during the third period, and no gain or perhaps a slight loss during the last 4 weeks. The latter is explained by the fact that limits of production are about reached, the work is "tailing out," odds and ends are being cleaned up and the work can not be carried as advantageously as earlier. Since the operations performed by the student are not repeated, the gain can be said to fairly represent an increased ability to perform work.

PRELIMINARY REPORT OF COMMITTEE NO. 12, ENGLISH.

C. W. Park, *Chairman*, University of Cincinnati; Frank Aydelotte, Massachusetts Institute of Technology; J. R. Nelson, University of Michigan; S. A. Harbarger, New York City.

The gradual return of normal academic conditions, following the S. A. T. C. period, is encouraging to the committee, since much work can now be resumed which had to be set aside last year. From communications that have been received since the re-opening of the colleges, it is evident that the temporary suspension of the usual courses has been in some respects beneficial. Instructors show a disposition to revise their subject matter and methods, and they bring to the revision a variety of experience and a fresh point of view, gained in some form of war service. The new start in all lines of instruction makes the time a propitious one for a re-examination and, where desirable, a reconstruction of the curriculum.

Fortunately, just when conditions are most favorable for the introduction of changes in materials and methods, the report of Dr. C. R. Mann on "Engineering Education" is available as a guide in reconstruction. The publication of this work at any time would challenge a testing of every instructor's work by the standards of engineering training which it sets forth. Its appearance at this time is highly significant.

Among the passages in Dr. Mann's report which bear upon the question of English instruction, the following are regarded by the Committee as being especially suggestive.

"With regard to instruction in English, the engineering schools may be divided into two approximately equal groups, the one composed of those schools that maintain the current standard college course; and the other composed of those that are trying to discover a type of work better suited to engineers. In the standard type of course, the student studies a

text-book of composition and rhetoric, learns the rules of correct punctuation and paragraphing, together with the four forms of discourse, and then writes themes on assigned subjects selected by the instructor to give practice in either description, narration, exposition, or argumentation. In some schools the strict adherence to this plan is mitigated by allowing a choice from among several assigned subjects. The accompanying study of literature consists of a brief survey of the lives of the great writers and the analysis of selected passages from their writings. This well-known type of course was developed during the latter half of the past century for the purpose of making English an acceptable substitute for the classics in high schools and colleges.

"Doubtless because the professional engineers have been so frank in their demand for better training in English, about half of the engineering schools are experimenting with their methods of teaching this subject. These experiments are so varied in plan and execution that it is not possible to classify them." (Chapter VII, page 42.)

"Therefore congestion of the curriculum is inevitable so long as each department remains sole arbiter of the content of its courses, and there is no coördination among departments with respect to the amount and the nature of the subject-matter in courses, and no scrutiny of the results of each department's work by some agency outside the department." (Chapter IX, page 56.)

"At this shool (Massachusetts Institute of Technology) English is a required subject for all students throughout the first two years. The first half of the freshman year is devoted to general composition, with the object of eliminating the more common errors of construction and of leading the student to see that excellence in writing comes not so much from the negative virtue of avoiding errors as from the positive virtue of having something to say.

"The work of the second term of the freshman year begins with a class discussion of such questions as: What is the difference between a trade and a profession? What is the mean-

ing of the professional spirit? What should be the position of the engineer in society in this new era of the manufacture of power—that of hired expert or that of leader and adviser? Is the function of the engineer to direct only the material forces of nature, or also human forces?

"Having discussed the question: What is engineering? the class proceeds in the same manner to wrestle with such problems as: What is the aim of engineering education? What is the relation between power of memory and power of thought? Is there any connection between a liberal point of view and capacity for leadership? What qualities do practical engineers value most highly in technical graduates? What is the relation between pure science and applied? What is the relation of science to literature? The authors read in connection with the discussion gradually change from engineers to scientists like Huxley and Tyndall, and then to literary men like Arnold, Newman, Carlyle, and Ruskin. The student seems to read this material with no less keen interest than was shown for the writings of engineers; so that through his own written and oral discussion of masterly essays each comes to work out for himself some rational connection between engineering, with which he began, and literature, with which he ends. No orthodox point of view is prescribed; his own reason is the final authority. The aim is to raise questions which it may take half a lifetime to answer, but the thoughtful consideration of which will give a saner outlook on life and on his profession." (Chapter X, pages 63–64.)

"Thus there is a widespread agreement among professional engineers that the college curriculum should aim to give a broad and sound training in engineering science, rather than a highly specialized training in some one narrow line; that considerable attention should be paid to humanistic studies like English, economics, sociology, and history, not merely because of their practical value to the engineer, but also because of their broad human values; and that the young graduate should have some conception of business management and

of the most intelligent methods of organizing and controlling men." (Chapter XIII, page 88.)

"The humanistic studies make up the fourth type of work essential to the training of every engineer. The professional criticisms of the schools indicate that this field offers the greatest opportunity for effective changes in current practice, because lack of good English, of business sense, and of understanding of men are most frequently mentioned by practising engineers as points of weakness in the graduates of the schools. The criticisms point out two types of weakness, namely, lack of technical facility in expression, in business, and in handling men; and lack of appreciation of and interest in literature, economics, and social philosophy. Clearly the humanistic departments are not alone responsible for these weaknesses, for no amount of drill in the technique of language will make a student write and speak clearly if he does not think clearly; and training in clear thinking is as much the function of the teachers of science, mathematics, and engineering as it is the function of the teachers of English. And if the professors in the technical subjects rigidly exclude from their instruction all discussion of human values and costs, is it reasonable to expect the students to appreciate economics and social science? As every one is aware, languages, economics, and social sciences are generally treated as 'extras' in curricula, and are as generally regarded as superfluous 'chores' by the students.

"The difficulty in present school practice evidently lies in the exclusion from the technical work of all consideration of the questions of human values and costs; and, conversely, the isolation of the humanistic studies from all technical interest. The theory has been that engineering at best is tied to materials; but that it can be made less materialistic by ignoring the question of dollars and cents in the technical work, and by teaching science, mathematics, economics, and literature for their own sakes entirely isolated from inherent technical relationships. This conception, however, is gradually giving way, for the experiments described in the last four chapters indi-

cate that technical work is more impelling, and is, therefore, more fully mastered, when it includes the consideration of values and costs; while humanistic work becomes significant, and therefore educative, when it starts from and builds upon the professional interest. And after all, the ultimate control of all engineering projects, as of all activities, is vested in some man's decision that the game is really worth while; and this control is likely to be more salutary, the more completely the man who decides comprehends the full import of the values and costs involved." (Chapter XIII, pages 92–93.)

"Because the appraisement of values and costs is the controlling factor in engineering, the final important change from current school practice that is suggested deals with the humanistic studies. The usual method of treating these subjects in short independent courses in the technique of composition, literature, history, economics, and so on, seems less likely than the method proposed (page 92) to develop the desired insight into these profound problems of value and cost. The experiments at Wisconsin and the Massachusetts Institute have progressed far enough to show how successful this type of work is with freshmen in developing powers of both forceful expression and appreciation of good literature. Therefore it seems reasonable to expect that the extension of this work into a consecutive course extending through the entire curriculum and consisting of live discussions and extensive study of the best that has been thought and said concerning the immediate and the ultimate values in life, offers the most promising solution of the problem of culture for engineers." (Chapter XIII, page 99.)

"The statement that individuality counts for as much as learning for the engineer, just as it does for the lawyer or the physician, seems like a veritable platitude. Yet because the engineering schools have always made it their chief aim to impart the technical information needed in industrial production, and because both scientific knowledge and industrial practice have grown so rapidly, the attention of technical schools has been focused chiefly on keeping up to date in

science and practice. The university emphasis on research in natural science has also tended to magnify the importance of technique and to minimize the importance of personality, until curricula have become so congested with specialized courses that students generally regard literature and sociology as unnecessary chores, to be endured rather than enjoyed. Therefore it seemed necessary to consider the question whether this emphasis on technique is producing a new and higher type of engineer, or whether the engineering profession still stakes its faith on the fundamental thesis that personal character is, after all, the real foundation for achievement." (Chapter XVI, page 106.)

"The organization of curricula proposed in Chapters XIII and XIV is suggested as one practical method of harmonizing the conflicting demands of technical skill and liberal education. It coördinates the results of numerous individual experiments in a consistent program. It recognizes all the essential elements and factors of engineering as well as the educational requirements of motivation and interrelation. It is not a utopian dream, but a summation of the best that has been thought, said, and done in education during the past two centuries. Finally, it embodies the modern conception of the professional engineer, not as a conglomerate of classical scholarship and mechanical skill, but as the creator of machines and the interpreter of their human significance, qualified to increase the material rewards of human labor and to organize industry for the more intelligent development of men." (Chapter XVI, page 113.)

In the brief synopsis which follows, the present scope of the committee's activity is indicated. Broadly, its aims are twofold: first, to stimulate discussion of current problems in English instruction for engineering students; and second, to act as a clearing-house for practical suggestions which may be useful to teachers of English in engineering colleges. The first of these objects contemplates a discussion which would interest not only teachers of English but also instructors, administrators, and others who deal with English chiefly as a

part of the general scheme of engineering education. The second object has to do with discussions of immediate practical or classroom value, including such exercises, outlines, and other "tricks of the trade" as may be used by instructors and students. Instead of requesting answers to a questionnaire, the committee invites instructors and others interested to send contributions of both kinds to the chairman. The general discussions may be based on the quotations from Dr. Mann's report, the topics suggested in the committee's 1918 and 1919 reports, or on any other subject of interest. The more brief and concrete the contributions, the more useful they will be. Sections of this year's report will deal with such subjects as "The Humanities in the Engineering Curriculum," "The Development and Expression of Individuality," "The Growing Emphasis on Oral English" and "Specialized Training in English for Engineers."

As an example of the kind of material which may be included under "practical suggestions," the following typical outline for a laboratory report is offered. This outline, it may be noted, was worked out by laboratory instructors in physics, electrical engineering and mechanical engineering on the one hand, and by a department of English on the other. The committee feels that on the more formal side of technical writing many such plans exist, which even if not adopted entire, would at least be interesting for comparison. In those even more important phases of instruction which cannot be classified, a concrete description of an instructor's method of approach may be widely useful if shared with his fellow instructors.

Typical Outline for a Laboratory Report.

Although laboratory reports differ widely in subject matter, the problem of organization is very similar in all of them. The outline given below represents a logical development of the subject as well as a convenient distribution of the material in the report of a test. With a few changes here and there to fit

special conditions, this form will be found serviceable in the writing of nearly every kind of laboratory report.

1. *Object.*—This division should consist of a clear, full, and concise statement of the object, preferably in the form of a simple declarative sentence. Since the report is not written until after the test has been performed, the statement should be put in the past tense; *e. g.,*

"The object of this test was to determine the steam consumption of a Brownell 10×12 engine."

2. *Theory.*—This division should contain a general statement of the data to be obtained in such a test, together with the fundamental principles on which the test depends. For example, the second paragraph of the report indicated above might begin as follows:

"In testing for steam consumption, the chief data to be obtained are (*a*) the horsepower of the engine, and (*b*) the weight of the steam passing through the cylinder in a given time."

Where formulas are to be applied in the test, they should be given in this part of the report.

Since the discussion deals with general theory, this section of the report should be expressed in the present tense.

3. *Apparatus.*—The apparatus used should be described, with emphasis on new apparatus and on special devices used in the particular test in question. At the beginning of the section, the various pieces of apparatus should be enumerated. New and special pieces may then be described in detail.

In so far as this part of the report deals with particular apparatus, it should be put in the past tense; *e. g.,*

"The apparatus used in this test consisted of the following," etc.

4. *Procedure.*—This section contains an account of what was done in carrying out the successive parts of the test. Care should be taken to omit preliminary and non-essential operations, and to follow the actual order in which the work was done.

The narrative should be impersonal, and should be given in the past tense and the passive voice; *e. g.*,

"Readings *were taken* at intervals of five minutes," etc.

5. *Results.*—(*a*) Summary of results: Conclusions drawn from the data should be stated briefly and clearly. In some cases it may be desirable to compare them with results obtained in other tests. (*b*) Curves. (*c*) Sample calculations: These may be brief, but they should be typical of the mathematical processes involved. (*d*) Data: The data should be presented on special paper designed for the purpose, and should be arranged in tabular form and in parallel columns.

6. *Sketches.*

7. *Original Data.*—Rough notes taken during the test should be submitted from time to time as evidence of the accuracy with which observations were made. If a log book is kept, it will answer the purpose.

Respectfully submitted,

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TECHNICAL ENGLISH: A DIAGNOSIS AND A PRESCRIPTION.

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The Committee on English of the Society for the Promotion of Engineering Education in the report for 1917 calls attention to the unsatisfactory preparation in English of recent graduates of engineering schools. A letter addressed by Professor J. M. Telleen to twenty-five prominent engineering companies, asking, among other things, for a statement concerning the English preparation of recent engineering-school graduates, brought replies from fifteen. The substance of these replies, so far as they relate to English preparation, is contained in a brief paragraph on page 220, PROCEEDINGS of the Society for the Promotion of Engineering Education, Vol. XXVI, 1917:

"To the question, Is the recent engineering-school graduate equipped with a knowledge of English sufficient for the work he is called upon to do?, two answered in the affirmative, eight answered with a positive No, and the others expressed themselves as being dissatisfied with the ability of the average graduate to use the English language."

Such a report is disturbing; if we had not for some time suspected the facts it lays bare it would be startling. It points, apparently, to some deep-seated trouble; and those interested in the teaching of English will be concerned with the situation and willing to spend some effort in an attempt to remedy it. But in mental no less than in physical ailments any attempt to apply a remedy ought to be preceded by a diagnosis. When once the seat of the difficulty is located, the means of improvement may follow as a logical consequence. It may then be worth our while to inquire whether our poor results have come from a failure to understand what we

should teach, from faulty methods of presentation, from a wrong student attitude toward the subject, or from something which is neither one nor the other of these things, but which is closely connected with the last two and in large part determines both of them. After these factors have been examined it will be time enough to put the question, "What shall we do about it?"

And what, in the first place, shall we say of the things we teach? Here at least there will not be much difference of opinion, and we need not therefore tarry long. The writer or the speaker must in the beginning understand how much of his subject the reader or the audience wishes to know, and must organize all the material he presents so that the main points will stand out with perfect definiteness. He must construct his paragraphs in such a fashion that they will in orderly sequence present the various topics which compose the different main divisions. He must write sentences whose structure reflects the thought they are intended to convey. And he must choose words which actually name the ideas he wishes to put into the mind of the reader or the hearer. These are the main things, the things on which all further study must be based. They commend themselves to the judgment of all thinking persons; and in one order or another all teachers of English composition cover them.

If we are substantially agreed as to what we shall teach, are we as fortunate in regard to the manner of teaching it? We must admit that on this point we shall find no such unanimity of opinion. We have had methods and methods; and when these have failed we have had other methods. Every new text has its method, and every teacher uses his own method, whatever the text he uses, and whether or not he uses any text at all. And then when we learn from the men out in the field that our technical graduates do not have a language equipment sufficient for the demands of their profession, we examine our methods and look about us for a text with a new and more appealing method. Our methods, we shall have to admit, have been as varied as our personalities.

Shall we then conclude our search at this point and say with some of the critics that the unsatisfactory English preparation of technical students is due to poor methods of instruction? Undoubtedly our methods are not yet perfect. But before we fix on the mere methods of English class-room instruction the responsibility for our failure, let us ask whether the methods of English instruction are fundamentally very different from the methods of instruction in other subjects. An English teacher may perhaps be pardoned if he professes no very extensive knowledge of methods used in the presentation of subjects other than his own. Most of us have, however, sat through from four to seven years of college instruction in various subjects; and we have probably not discovered from this experience much closer agreement as to class-room method among other teachers than among teachers of English. In the teaching of other subjects, no less than in the teaching of English, personality determines method; and unless we are to believe that English teachers as a class are deficient in personality, the difference in results obtained must be sought, very likely, elsewhere than in difference of method.

Where, then, shall we turn? It will do no harm to inquire into the attitude of the technical student toward a study of language. And here for the first time light begins to break in upon our problem. The average teacher of English will tell you that the average technical undergraduate is not enthusiastic over his English.

"We should rather have our time for our practical subjects; we want something which we can turn to practical account when we get out of school." This is what he will tell you when you get close enough to him to find out what he is really thinking. And in this confession of faith we come pretty close to the location of the language problem. In spite of the favorable attitude of technical men both in and out of college the average technical undergraduate, because he thinks the study of English impractical, finds it far from attractive.

How prevalent this lack of interest really is may be illus-

trated by a recent experience of an English teacher. A sophomore engineer in one of his classes had done rather better than average work. The teacher was, therefore, surprised and somewhat taken aback when the student came into his office soon after the close of the semester.

"Didn't you find your report satisfactory?" the teacher asked, reaching for the student's papers in the hope of confronting him with a misspelled word or a dangling participle.

"I don't mean that," he said, observing the teacher's distressed look. "But you wrote on one of my papers that I could improve my style by studying the works of good writers. I thought you might tell me where I could find something good." The teacher looked at the young man a moment, and then, getting his point, handed him a book. As soon as the student left, the teacher hurried in with the news to the chairman of the engineering group of English teachers. The latter was as much impressed with the novelty of the occurrence as the teacher had been.

"Remarkable," he declared; "take a note of that; it's worth remembering." This young man he found so unusual as to merit more than passing notice, for he, too, understood that the average technical student is not fond of English.

To be sure, there are exceptions to this generalization. A good many technical students do value training in English at something near its real worth, and give it serious attention. Some instructors, too, with rare skill succeed in gaining the interest of their classes and in adding to the number of those who value such training. But with grateful acknowledgment that both this kind of student and this kind of English instructor exist, we accept neither as typical and return to our generalization as a safe working hypothesis.

But all this is no news. Both English teachers and teachers of technical subjects have for a good many years recognized that technical students do not love English, and have tried to remove their distaste for the subject. Most of our search for an improved method has been inspired by our eagerness to present our subject in an attractive manner, be-

cause, feeling sure of what we should teach, we have been certain that in so far as we failed our failure was due to a lack of appreciation on the part of those we tried to teach.

A few years ago we thought the way out lay in the direction of segregation. If students of engineering could be grouped in classes by themselves and permitted to write on engineering subjects, or better still, if civil engineers could be grouped in one section, electrical engineers in another, mechanical engineers in a third, and so on through the range of the engineering departments, they would find the subject more attractive, and their composition would improve. But in some of our technical institutions more than one college generation has grown up under segregation, and although the plan is very likely a step in the right direction, it is still not evident that the solution of the language problem has been found. Under segregation the attitude of technical students, always with exceptions, of course, has remained substantially what it was before, because they still question the usefulness of the training required of them. Segregation has not removed the technical student's objection to language training, because the lack of segregation was not in the first place responsible for that objection.

Now what has happened in the case of segregation will probably happen in the case of other proposed remedies unless our diagnosis goes further than it has yet gone. It is not enough to say that the unsatisfactory English equipment of technical graduates is due to a lack of interest in the subject while they are undergraduates. It is not even enough to explain their lack of interest by saying that they do not class English composition as one of their practical subjects. We can not proceed with any confidence until we have inquired why they do not so class it.

And when we come to this inquiry we must not advance too rapidly, for the trail is not too well traveled. But there are at any rate certain marks which may keep us from losing our bearings. We can not, in the first place, throw the blame upon technical men engaged in the practice of their pro-

fession. In address after address, and in article following article, they have given testimony to the importance of adequate expression. Indeed, it is chiefly on account of their dissatisfaction that we are now so much concerned over the matter. Nor can we, in the second place, accuse technical men within college walls of any unfavorable attitude toward the study of English composition. Almost without exception the heads of technical departments have been generous in according time to the subject, and English teachers pay tribute to the willingness with which technical faculties have met their advances. The attitude of technical men, both in the professions and in the colleges, has been most favorable to the teaching of English.

It may, then, seem strange that undergraduates in technical schools do not share this favorable attitude. But let us not too hastily condemn even them. They are for the most part earnest, hard-working students; and they are the raw material from which technical men, in and out of college, are to be made. When they have left college behind them they will themselves writes articles and deliver addresses in favor of English training. This being the case, if we find them nevertheless through succeeding generations of college life consistently discounting the study of English composition, we ought to seek the explanation for this apparent inconsistency within the college. Since, however, we have in one way or another managed to exonerate all parties of blame as to method or attitude, we must look for the seat of the trouble, apparently, to something deeper than method or even attitude.

Now, the only thing which seems to go deeper than either method or attitude is a failure to make the technical student see that English composition is a study fundamentally different from any other study in the curriculum. The sanitary engineer studies bacteriology because it lies at the roots of his profession; the electrical engineer, if he studies bacteriology at all, does so, probably, not because he expects to make any professional use of the subject, but because he wishes to know something of science outside his own pro-

fession and happens to have been attracted by bacteriology. If his taste had been different he would have elected botany instead, or perhaps zoölogy, or psychology. And so it is, with a single exception, throughout the entire field of human knowledge. Any subject which finds its way into a course of study leading to any given profession is chosen always for one or the other of two reasons: either it contributes a store of ideas necessary to the pursuit of that profession, or it helps to broaden the outlook of the professional man by supplying him with ideas outside his profession. English literature, along with bacteriology, botany, and the rest, belongs in the latter class of studies. The teacher of literature or the literary critic must study literature, because it furnishes him his stock in trade. But the engineer, if he studies literature at all, does so because he thinks it has cultural value, because, as one prominent engineer in his lifetime would have put it, literature increases his "competency to appreciate and enjoy." Thus we find it everywhere: all subjects, save only one, are capable of this double classification: for some professions they are essential, for others merely desirable.

And this one exception, of course, is English composition. Since it is the medium for the communication of thought in all fields of activity, it follows that its relation to every other subject is precisely the same. Language in one form or another, good, bad, or indifferent, we must all use whenever we have a thought to express.

We can not, however, get past this point without an objection. We have long recognized the importance of English training, some one says, and have required it in practically every course of study, technical as well as cultural. Almost no school now grants a degree in liberal arts, in pure or applied science, without more or less work in English. It is a sufficient answer to this objection to say that our failure to make the student understand the subject of English composition does not lie in any failure to make him pursue the subject. Every school, to be sure, has its department of English; some schools have a dozen or more separately numbered courses

in English composition. In some one or more of these courses practically every student is required to register. He is required to write a certain specified number of papers, of a certain specified length, on certain specified topics, frequently not much to his liking; and along with these papers he does more or less oral work. During this time there is held before him a standard of expression rather high, sometimes so high that he does not see its logic. If he falls below this standard his paper is returned to him and he is required to make corrections in red ink or to rewrite the assignment. We have made the student understand pretty thoroughly that he must study English.

Have we made him understand as well that he must actually use his knowledge of English anywhere except in connection with his formal study of the subject? The answer is not far to seek. While his formal English work is going on the technical student is doing other writing and other speaking of a different sort. In connection with laboratory experiments, inspection trips, and other kinds of practical work he is frequently called upon for reports; and in connection with seminars he sometimes has to present topics orally. And, finally, before graduation, he has to present a thesis, a composition of greater volume than he is likely to be called upon by his English teacher to produce at any time during his college career. Altogether the technical student in a great many cases, does, perhaps, more writing and speaking outside his English courses than within them.

All this outside work has had from the beginning rigid supervision from the standpoint of its technical content. But until recently the English teacher has not been required to pass upon its form. In all probability it has been a source of satisfaction to some students to imagine that the English teacher has not been permitted to pass upon its form. We have required technical students to classify in certain courses of English composition, and have trusted that they would make use of the principles there studied in whatever written or oral work their other courses required them to do. But

with very few exceptions we have made no attempt to check this written or oral work to see that they actually do make use of these principles. We have not yet generally so organized our English instruction that the teacher of English knows very much of what his students write or talk about other than in the pursuit of their formal study of English. Indeed, in some schools even to-day it would be considered improper for a student to present as an English exercise any written work for which he had received credit in some other subject. And so he goes through college, writing for his English courses papers in which the manner of expression is considered more seriously, perhaps, than the subject matter, and for his technical courses papers in which the manner of expression is at least not emphasized, in which it is at times almost ignored.

If the situation here presented with reference to the organization of our English instruction has not been overdrawn, what is its bearing on the English problem? What is the technical undergraduate likely to think of all this praise of English training from technical men outside the college, of all this piling up of English courses by the heads of technical departments within the colleges? The old proverb supplies the answer: Example is better than precept. The undergraduate will not look very far beyond the face of the returns. He will not easily see the necessity for a standard of expression higher than that which is required of him in his technical courses. As long as there is a difference between the standard of expression in his English courses and in his technical courses he will choose as his standard that which is set up in his technical courses, not because it is lower, but because he assumes it to be the standard of his technical instructor.

This, then, in brief is our diagnosis: our technical graduates write poorly because as undergraduates they consider English composition a subject of no great practical importance. They take this attitude because of the double standard of expression fostered by the present organization of our English training. This organization has grown up because we have not generally in the past ourselves understood the funda-

mental difference between the nature of English composition and the nature of any other subject in the curriculum. That is to say, we have in our teaching segregated a subject which by reason of its peculiar constitution can flourish only when widely distributed throughout the remaining subjects in the curriculum.

If this diagnosis is accepted as sound it will not take long to write the prescription. Since the relation of English composition to all technical subjects is the same it would seem logical to standardize the requirements in composition in all technical courses of study. A minimum course in English for all technical schools should give to formal class-room study just so much time as will suffice to present with perfect clearness those principles which are actually usable in writing and speaking. The student should do less writing than he now does in most cases on assignments made by the English instructor; but every paper he writes in the study of any subject, technical or cultural, during his entire course of study should pass not only under the eye of the instructor making the assignment, who would judge its content, but also under the eye of the English instructor, who would judge its form. To this minimum course there should be added other special work elective for those students who show aptitude for expression and are likely to become writers or speakers.

The plan here suggested in barest outline is not proposed as a panacea. We have tried so many disappointing remedies that a modest person ought to have some suspicion that he may be himself a quack. But the plan has at least the merit of consistency: it compels the technical student in the preparation of those papers which he is most likely to consider practical to use the principles of writing which in the English class-room he has studied and seen illustrated; and it ought to make impossible in the mind of the student any notion that his technical instructor, in spite of a theoretical approval of good English, is after all not deeply concerned over the student's poor English.

Before the plan is pronounced radical let it be remembered

that already a good deal has been done which points toward some such step. In the report of the Committee on English referred to in the beginning of this article, page 222, among the recommendations for the improvement of English offered by the managers of engineering companies, we find this language: "The written work required by the engineering departments should be submitted to the department of English for criticism; the students should be graded for the English they use in the recitations of all departments; the same weight should be given to correctness in the English of experimental reports that is given to exactness in mathematical calculations." Recently, too, in a number of schools the papers written in certain technical courses have been passing through the hands of English teachers. The current is setting strongly toward a more thoroughgoing coöperation between teachers of English and teachers of technical subjects; and out of the clearer understanding of our problem which is responsible for this coöperation there should come in time some improvement in the English equipment of future technical graduates.

REPORT OF COMMITTEE NO. 14, ECONOMICS.

The committee has had no meetings, but has conducted its work by correspondence as before. The committee has no recommendations to make, but submits the following progress report as information.

Opinions of Practicing Engineers Concerning the Teaching of Economics to Engineering Students.

The committee sent the following brief questionnaire to fifty engineers who have been eminently successful in the practice of their profession with a view to ascertaining the opinions and attitude of representative engineers not engaged in educational work concerning the teaching of economics to engineering students. The letter accompanying the questionnaire made mention of the fact that no attempt was being made to seek arguments either for or against the teaching of economics, but that frank and unbiased opinions only were sought.

Group.	Number of Replies.	Question No. 1. Does Economics Aid Professional Success.	Question No. 3. Character of Course.
Civil engineers	15	12 yes	General principles 5
		1 no	Special topics 2
		2 no opinion	General principles and special topics 5
			No opinion 2
Mechanical engineers.	8	5 yes	General principles 4
		1 no	Special topics 2
		2 no opinion	General principles and special topics 1
			No opinion.....1
Electrical engineers ..	4	3 yes	General principles and special topics 3
		1 no opinion	No opinion.....1
Mining engineers	2	2 yes	General principles and special topics 2
Architects	3	3 yes	General principles and special topics 3

Not all of the engineers addressed submitted replies, the percentages of replies being as follows for the different groups: civil engineers 75 per cent., mechanical engineers 80 per cent., architects 60 per cent., electrical engineers 40 per cent., mining engineers 40 per cent. The answers to Questions 1 and 3 are tabulated below:

1. Has your experience as a practicing engineer indicated that the course in economics pursued by you while in college has aided in your professional success? .....

If you did not pursue such a course in economics, is it your opinion that such a course would materially aid in the successful practice of engineering? .....

2. If so, please state briefly in what way a course in economics has contributed to your professional success (or would contribute).

.....
.....
.....
.....

3. What sort of a course in economics would you consider the most valuable for an engineer? That is, should it deal with the general principles of production, exchange, distribution and consumption of goods, or with some specific question, such as labor and wages, banking, corporation finance, accounting commercial geography. .....
.....

4. Do you object to having your replies as given quoted? .....
.....

Note.—By economics as used above is meant the subject as taught in colleges under that caption and refers to the science of wealth. It does not refer to economy of design or construction as used by engineers, it being assumed that this latter subject will be taught in connection with the special technical subjects.

(Signature) .....

With regard to the answers to Question 2, the general purport was that a study of economics would enable the engineer to comprehend more fully the relation of his work to the whole economic fabric of the country. The following quoted replies to this question are expressions of fairly definite opinions on this point.

"Would give the engineer a better understanding of the results he is endeavoring to obtain."—Albert F. Reichmann.

"It (economics) gives an engineer a broader field of thought and enables him to solve problems, especially larger projects, etc., in a more logical and better way. An engineer, in order to succeed, must not limit his education to strictly technical subjects."—Ralph Modjeski.

"The knowledge that would have been gained through a course in economics—particularly with regard to such questions as corporation finance and accounting—I am sure would have been of great assistance to me in my work, and especially in connection with the reports to the larger corporations and municipalities during the past twenty years."—Bion J.Arnold.

"It (economics) has caused me to comprehend better than otherwise the trade conditions of our country, the import of building materials, the several crises and panics that have occurred in the last sixty years, the wisdom or futility of undertaking certain public works and the estimation of their value and cost."—Rudolph Hering.

"My work requires a sound knowledge of the fundamentals of financial matters, for I am frequently called upon to report upon projects and properties. Engineering is not technical only, but includes a sound treatment of the financial side of all projects. It is even more necessary for an engineer to know whether a development should be made, whether it will pay, than how it should be made."—John Lyle Harrington.

"It (economics) enables one to view a situation broadly, considering such elements as public policy, labor, transportation, public welfare, etc., in a problem which might otherwise be studied from a narrow viewpoint of direct costs only."—H. J. Burt.

"I think such a course would broaden the engineer who has specialized too much in the past."—Hunter McDonald.

"Business principles are as essential to the engineer as mathematics. The broader his education in corporation finance and allied subjects, the better his chance for administrative positions. A large percentage of engineers work for

corporations and they should know all about them. I am sure that a good ground work along these lines would be of material help."—E. J. Collins.

"In giving me a basis to which in later years I could revert and analyze the complex relations of capital and labor and the rights of the public."—Bert H. Peck.

"A comprehension of the general laws governing the production and consumption of wealth as well as their application to the specific problems of life enters into the genesis of all successful engineering undertakings. Otherwise, the success of the undertakings depends on luck."—L. E. Imlay.

"As the ultimate object of most engineering work is reduction in the expense of accomplishing some definite process, any training which enables an engineer to thoroughly grasp the relation between the work in hand and its financial results will contribute largely to his profession and success."—Chas. F. Uebelacker.

"A course in economics would undoubtedly have broadened my viewpoint in the earlier work and laid the foundation for clearer thought in the executive position."—Edwin B. Kattel.

"Some knowledge of financing, accounting, securities, business law and business management would have been of assistance."—Charles T. Main.

Mr. Clemens Herschel and Mr. H. L. Gantt do not believe that a course in economics as at present taught would contribute to the successful practice of engineering in any way.

The following are some of the suggestions which a few of the engineers addressed volunteered as to the proper content of a course in economics for engineering students.

Dr. Rudolph Hering says: "Most of the questions of this branch of social science are more difficult to understand than questions of mathematics, physics, geology, etc., because they are much more complex and spread over a larger field and because their practical conclusions must vary with the different stages of development as they are reached by society."

"Of all social sciences, economics is therefore one of the greatest importance. It comes next to ethics, of which it is to

some extent a corollary. And all movements to instruct our youth concerning this branch of science are to be most highly commended and furthered."

"I am of the opinion that a competent professor should be able to impart such a course in two semesters at one hour per week."

Mr. Gustav Lindenthal with much the same opinion suggests that economics be taught only in a post-graduate course, since "especially the science of finance requires a very mature mind, certainly more so than [does] higher mathematics or applied science. The present theories are mostly wrong, being based too much upon authority worship and not enough upon scientific analysis, which is considered heretical by banking interests, whose constant efforts are directed towards a higher rate of interest on capital and a lowering of wages instead of the reverse principle."

Mr. H. L. Gantt also is not satisfied with the present tenets and doctrines of economists. He says: "To be perfectly frank with you with regard to the subject of economics, it has been impossible for me to have any patience with the ordinary text-books on economics. They are all written apparently to support certain theories of their authors, and in many cases have but little to do with practical conditions which now obtain."

"In general, books on economics are written from the standpoint of trade and not of production. They were perhaps more or less helpful in the days when trade was the controlling factor in the world. With the rise, however, of modern industrialism, production has become the controlling factor, which throws all previous theories out of gear. The fact that production has become the controlling factor was clearly demonstrated during the war, and is now being demonstrated in Europe. Unless the economics problem is studied and taught from this standpoint, I regard any teaching on the subject as not only of no value, but positively detrimental."

Mr. Leonard Metcalf calls attention to the present urgent need of teaching economics. He says: "It is my personal opinion that the obligations of institutions of learning to the public

practically compel the giving of courses in economics at the present time. The present undergraduate bodies in our colleges have had practically no experience or observation in the application of such fundamental laws as that of supply and demand. They have lived since they began to notice such matters in the press and conversation, in a thoroughly abnormal era, with government control of prices, labor and industry. They accept without question as normal the results attained, failing to recognize as older, experienced men do, that these results were possible only with the mind set on one purpose—the winning of the war. They do not recognize that in times of peace, many and probably the majority of men would not tolerate what they accepted willingly, or permit the President and Congress the full measure of power that they willingly gave during the war. Therefore, it seems to me that the most difficult task faced by the institutions of learning the world over is giving the student, in a way that will stick in his memory, a clear picture of the world up to this time and of the operation of well recognized economic laws under normal conditions."

"Unless our institutions of learning and public leaders recognize this and do what they can to broaden the horizon of the student body, there will be tried many economic theories already demonstrated as unsound, an impetus will be given to uncontrolled radicalism and thoughtless socialistic propaganda. There never has been a time probably when there was greater need of open-minded and careful review of old theories than at the present time, but it would be deplorable to lose the crystalized experience of past centuries."

Mr. B. H. Peck outlines somewhat in detail the character of a course in economics that he would consider the most beneficial. "It (the course in economics) should, in my opinion, not be presented by one man, since we all have our peculiar biases and beliefs on subjects of this nature. If I were framing such a course, I would include lectures by financial men who could explain the flow of money to certain fields, and the interest requirements of invested capital; by labor represen-

tatives, who could state the attitude of labor and its aims; by an advocate of municipal or government ownership; by a practical operator of a large enterprise; by a tax commissioner; by a public utility commissioner, etc. Along with these, I would study Smith's 'The Wealth of Nations' or its modern equivalent."

A perusal of the replies reveals a notable lack of uniformity and definiteness of conception on the part of practicing engineers as to the use of the term economics. To some, it apparently applies to the actions of social communities, while to others, it is limited to the details of more or less private business transactions.

The general tenor of the replies is in accord with the report of the committee last year, wherein it was recommended that the formal study of economics consist of a three-hour outline course in the general principles of the subject. However, there is a suggestion in a number of the replies that sufficient time should be given to some special topics, such as labor problems, commercial geography, accounting, corporation finance, public finance, etc., to cause the student to appreciate their importance and to grasp their significance.

Movement Toward Extension of Teaching Economics.

The Bureau of Education in the Department of Interior is fostering the development of courses in "Commercial Engineering" to be given in schools of commerce and to embrace the fundamentals of engineering courses with extensive studies in economics and allied subjects. The courses are planned with a view to preparing men for administrative positions with large corporations and other business concerns. A preliminary conference was held at St. Louis, February 22, with Dr. G. L. Swiggett, of the bureau, as chairman. A second conference was held at Washington, March 31, and it is proposed to hold a third at the same place on Monday and Tuesday, June 23 and 24, immediately preceding the annual meeting of the S. P. E. E. This conference group has

not yet issued any conclusions for publication other than to make the following tentative recommendations:

1. That from twelve to eighteen semester hours be required of all engineering students covering the following subjects: general economics, cost accounting, business organization and business law.

2. That for engineering schools desiring to extend further the commercial or industrial aspects of engineering, the following subjects are recommended as electives: labor and employment, corporation management and finance, statistics, marketing, scientific management, psychology, transportation, political science.

3. That the economic phases of engineering be emphasized in engineering instruction wherever possible.

A few schools have already instituted courses of the character contemplated by this conference either as a department of the engineering division or as a coöperative arrangement between the engineering division and the school of commerce. Massachusetts Institute of Technology has such a course under the heading Engineering Administration, with three options as follows: civil, looking to administrative positions in transportation, hydraulic power and construction enterprises; mechanical, in preparation for similar positions in machine manufactures; chemical, in preparation for such positions in various chemical manufactures. The University of Kansas, in the School of Engineering, offers a similar group of courses under the heading Engineering and Administrative Science, with two options, civil and mechanical, and Pennsylvania State College offers a course called Industrial Engineering that is similar to the above. The universities of Illinois, Wisconsin and Ohio maintain coöperative courses in transportation or other phases of commerce which combine engineering with economics in the schools of commerce.

Courses in Citizenship.

Recently, the University of Illinois voted to institute a course in "citizenship" to be required of all students in the

university. The schedule will consist of two courses of three hours each, the first including history and those phases of economics and political science that are fairly definite and generally accepted, and the second, those phases of economics and politics that are more or less controversial in their nature. The scheme is an outgrowth of the war issues course of the S. A. T. C. regime.

The oject apparently is not so much to furnish the student with information and training that may be of direct professional benefit as to equip him for the duties of citizenship. The courses will be taken by all students subsequent to their freshman year, preferably in the junior or senior year.

The University of Wisconsin has installed a similar scheme under the title of "Americanization" with a professor in charge.

Influence of Present Economic Status on Instruction in Economics.

The committee desires to call attention to the desirability of recognizing the abnormal state of industrial affairs in connection with the teaching of economics and to urge the importance of laying emphasis on sound economic doctrine, such as is the best product of past human experience and such as will lead to stable industrial conditions, rather than spending the time of the class in the consideration of radical and untried theories of social and industrial organization. The teaching of sound economic doctrine in colleges will be one means of hastening the inevitable return of the economic pendulum to the mean position which is so necessary for further industrial development.

The extensive realignments in domestic and foreign trade render imperative a study of commercial geography on the part of engineers interested in manufactures and in markets. Attention of students should be called to the altered position that this country now holds in the world's markets and commerce, to the changed labor situation, etc. This can be accomplished best perhaps by some other instrumentality than

formal class exercises, such as posting bibliographies of meritorious articles, etc.

INTEREST IN ECONOMICS.

The committee believes that an endeavor should be made on the part of engineering faculties to aid in overcoming the apathy generally manifested by engineering students towards economics and to foster in them a live interest in the subject. Conscious effort in this direction is probably the only means of securing satisfactory results in the subject to engineering students.

Respectfully submitted,

A. B. MCDANIEL,
E. B. PAINE,
W. G. RAYMOND,
C. C. WILLIAMS, *Chairman.*

Professor G. F. Swain, the other member of the committee, declined to approve the above report.

THE METRIC SYSTEM IN ENGINEERING.

BY FREDERICK A. HALSEY,

Member and Commissioner of American Institute of Weights and Measures.

(Presented at the meeting of Section D, A. A. A. S., Baltimore, Md., December, 1918.)

I desire to introduce the subject proper of this paper with a few remarks regarding the value and importance of standardized things.

We make infinite effort to standardize mechanical constructions, and when the work is done the standards accomplish their purpose so perfectly and work with so little friction that we forget the purpose for which they were established. Most of those who oppose the metric system, when confronted with the suggestion of a change, throw up their hands with the remark "Think of the cost of scrapping our special tools, fixtures, and gages and replacing them with others made to the metric system." While this instinctive objection is of large importance, it represents but a trifling fraction of the value of standardized constructions and in order to make this clear, I will point out two examples.

The couplings with which the hose ends of railway car air brakes are connected were standardized, that is, made interchangeable, many years ago at the works of the Westinghouse Air Brake Company. Because of that standardization, railway cars—both passenger and freight—when fitted with air brakes, may be made up in trains regardless of the railroads of their origin and transported throughout our country. What would be thought of a man who would estimate the value of those standardized couplings in terms of the cost of the special tools with which they are made in the works of the Westinghouse Air Brake Company? Is it not perfectly

clear that their real value lies in the results which they accomplish, that is, the possibility of interchanging cars between railroads?

As another illustration, consider standardized pipe fittings. Because those fittings are standardized, they are made by the million and may be bought at trifling cost in any pipe fitting shop. The piping of a building consists of little more than cutting pipe to length, threading its ends with standardized dies and assembling the resulting pipes with their connections and fittings. Consider the conditions that would obtain when piping a building for steam, water and gas were it necessary to make each fitting for its place and to order, and then ask yourselves what part of the real value of standardized pipe fittings is represented by the cost of the taps and dies with which the threads upon the pipe and fittings are made. Additional examples could be given without number, but these two should be sufficient to show that the value of standards lies in the results which they accomplish and not in the tools with which they are produced.

Consider, next, the result of attempting to change the sizes of air brake hose couplings to metric dimensions and the infinite cost and confusion that would result. Air brake hose couplings are standardized in order to facilitate the interchange of cars which the present standards accomplish perfectly. Were those couplings changed to metric dimensions no gain would result since the new couplings would accomplish their purpose no better than the old. Similarly, pipe is made to carry steam, gas and water and if our pipe sizes were changed to metric dimensions, the new pipe would accomplish that purpose no better than the present pipe, while in both cases the cost measured by the resulting confusion would be prohibitive.

These things will not be changed because they cannot be. We may pass laws for the adoption of the metric system until the crack of doom, but such things will remain as they are. They supply two illustrations that might be repeated to the

point of weariness, but they are sufficient, and they point out what we must consider in the event of the adoption of the metric system, namely, the use of that system in connection with standardized things made to English dimensions for the indefinite future, for the simple necessity of continuity makes the continuance of the existing sizes of standardized things imperative. We must consider, therefore, not the hypothetical condition of the metric system standing alone, but the actual condition of the conjoint use of both systems—one in materials of construction and the other in engineering calculations.

Let us, therefore, consider the conditions to be met after the metric system has been adopted but while existing structural standards continue in use. To make this clear, I have selected some of the simplest possible illustrations in order to point out a universal principle, and this is the real subject of my paper.

Technical Literature Must be Rewritten.

Take the simplest possible case—finding the size of a bar of steel to carry a given load in tension. We place the load on one side of an equation of which the other side includes as factors the required area of the bar, the tensile strength of the material and the factor of safety. We write the load in kilograms and the tensile strength in kilograms per square centimeter and find the required area of the bar in square centimeters, to be at once confronted with the fact that all American merchant bar is rolled to diameters in inches. We, like metric countries, have plenty of tables of areas, but in all cases they connect diameters and areas in the same system of units. With either system used alone we would, after finding the area, take the diameter directly from a table; but we must now find the diameter in inches from the area in square centimeters by calculation, until such time as someone has prepared and printed a transition table giving diameters in inches and areas in square centimeters, or, by first finding the diameter in millimeters and then converting the result to inches.

An alternative procedure is possible. The formula might

be altered into a transition formula giving the tensile strength in kilograms per square inch and the area in square inches. We could then use existing tables of areas, but in addition to the transition formula we would need transition tables giving strength in kilograms per square inch. Such tables must be prepared and printed before this procedure is feasible. Whatever the procedure, we shall at the end have the same result —that is, the same load and the same bar, to get which we have discarded existing tables and made the calculations which the tables have been prepared to avoid.

I have gone into this in, perhaps, tedious detail, because it illustrates in the simplest possible way a universal principle: Whenever basic quantities—loads, powers, velocities, pressures, capacities, etc.—are expressed in one system of units while commercial materials are made to, and their properties are recorded in another, we have a conflict in every application of one to the other. Existing formulas, English or metric, do not fit, and existing tables do not apply. To suit this condition, our technical literature must be rewritten from the beginning in transition form for use so long as existing commercial sizes of materials continue in use to be discarded when, and if, the transition period comes to an end.

Illustrations of this may be multiplied to the point of weariness. Suppose we are laying out a belt transmission. The formula for the capacity of belts includes the velocity and width of the belt, with other factors. Our reference books contain charts that give the effects of speed, centrifugal force, thickness, type of joint and arc of contact almost at a glance, but these we must discard and make the calculations which the charts have been prepared to avoid.

With the load in metric units, this calculation gives us the velocity in meters per second and the width in millimeters; but when we take up the matter of pulleys, we find that all pulleys made in this country are made to inches of diameter which, multiplied out, give the circumferential velocity in feet per minute, and this result we must equate with belt

velocities in meters per second. Ultimately, we must use the pulleys we can buy—that is, of English diameters and widths.

Going further, we determine the shaft sizes, to be confronted with an applied torque in meterkilograms equated with the resisting torque of a shaft in inches of diameter, on which the only available information as regards torsional strength is in pound-inches. As before, we need a transition formula and tables giving, in this case, resisting torques of shafts in kilogram-inches, and as before, we get the same result in the end.

Since closeness of fit is not involved, we may still place a belt of metric width on English pulleys, shafts and bearings; and then, if we are true-blue metric advocates, we will shout from the house tops: "We have adopted the metric system."*

Do we calculate the diameter of a pipe or a boiler for a given pressure, it is the same. From the pressure in kilograms per square centimeter we get the stress in kilograms per square centimeter, to be equated with the strength of the material, of which the thickness is in inches, and all available data for strength are in pounds per square inch.

Do we calculate the weight of structures, it is again the same. We have extended tables of the weight of materials in pounds per foot of length; but if we are to use the metric system with these materials, we must have transition tables for I-beams, channels, angles, bars, pipe, sheets, etc., giving weights in kilograms per meter of materials rolled to inches of cross-section.

* This is not sarcastic, but descriptive of every "adoption" of the system of which I have any knowledge, all such adoptions being partial. The metric enthusiast makes the easy changes. He does not make the difficult ones, but he invariably talks as though he had made them all. He regards the difficult changes that he has not made as not worth counting. If we are to study difficulties, we must study difficulties, the changes which he does not make because he cannot, and does not count because it suits his purpose not to, being the very ones that must be counted.

All Technical Tables Must be Recalculated.

The matter of the tables is perhaps of even greater actual, though less fundamental, importance than the formulas. Our tables are now so complete and comprehensive that the large majority—in some applications perhaps 80 per cent.—of such problems are solved by direct reference to them, resort to the formulas being had only for occasional cases beyond the range of the tables. All our tables are based on one system of units. We have no tables for a mixture of units; and until someone has been good enough to prepare and print them, we must resort to calculations which the tables were prepared to avoid and, so long as existing materials are used, get the same result in the end. What is gained? What is it all for?

As another illustration consider the most ordinary problem in hydraulics—finding the diameter of a pipe to carry a given quantity of water. Hydraulic tables are remarkably complete, and most such problems are solved by simple reference to them. Using the metric system, we have the head, the velocity and the length of the pipe in meters and the discharge in liters, but the diameter of the pipe is in inches. We have neither formulas nor tables fitting this condition, and again we must calculate and convert, our calculations in this case involving the square root of the fifth power in millimeters of pipe diameters in inches. The results of these calculations we now take directly from the tables, and again the final result is the same.

In the foregoing cases we have to deal with repeated conversion of units, which while bad enough, is not all. Let us therefore consider one more everyday case in which even this will not answer—finding the size of an I-beam to carry a given load. Our span is in meters, and our load in kilograms, but the cross-sections of our beams are in inches. What shall we do with the moment of inertia? In the moment of inertia of an I-beam four dimensions enter, two by their first powers and two by their cubes. There is no possible conversion factor between English and metric moments of inertia. Moments of

inertia of all common cross-sections in English units have been worked out and tabulated in great profusion, but we cannot use them even by conversion. Until new transition tables of metric moments of inertia of sections rolled to inches have been prepared and printed, every calculation of an English section I-beam for metric loading involves the calculation of the moment of inertia for the cross-section or, as an alternative, the use of English units for the load and span. Which will be done?

A Few Examples.

Following is a list of a few such tables that will be needed: Square roots of fifth powers in millimeters of pipe diameters in inches; weight of materials in kilograms per cubic inch; board measure; section moduli, radii of gyration and squares thereof and areas of rolled sections; friction head and discharge of pipe; weight of all rolled sections and of rivets, bolts, bars, balls, plates, pipe—cast, welded, cold drawn, etc.; strength of columns and pillars; strength and weight of chain and rope—wire and hemp; weight and other properties of brass copper and lead pipe and other products of these materials; strength and other properties of timber beams, columns, etc.; properties of boiler and condenser tubes; bursting and collapsing strength of pipe; pipe flanges; flow of air in pipes; all screw-thread and gearing tables; chain-driving tables; the strength of riveted joints; angles when considered as tapers per foot; chord-spacing tables of circles; weights and other properties of all materials made to wire and sheet metal gages; loads on bearings; strength of shafting; strength and deflection of springs; all machine-shop standards—tapers, dovetails, machine parts and details, press and running-fit practice, etc.; performance and power requirements of machines in endless variety; strength of materials of all kinds and grades; steam-engine and boiler practice from the ground up. But the list is endless. Open any engineer's reference book and look for a formula or a table (other than mathematical tables, which are universal) that will be useful during the

transition period, and you will look long before finding one.

Of these two requirements in preparation for the transition period the transition formulas will come first. We shall then be in shape to use the metric system, provided we are willing to discard all tables that have been prepared through many decades to shorten, and, in many cases, eliminate calculations, the physical result being the same in all cases and the psychological result the proud and superior consciousness that we are "using the metric system."

We are to discard these devices for saving time in calculations and make the calculations which they make for us, in the cheerful belief that the loss will be compensated with a balance to the good through the magic of the "beautiful interrelation and correlation of the units." This is the hook which engineers are asked to swallow, and by all that is logical, the proffered bait is economy of time in calculations!

One who is familiar with these problems will recognize that many of them must be solved by successive approximation or trial and error. With the tables we soon find the appropriate size; but when calculation is resorted to, we must calculate and recalculate until a satisfactory result is found.

All this leads to but one conclusion: So long as existing commercial sizes of materials of construction endure, no sensible man will resort to metric calculations with them more than once.

Who Will Lead the Procession?

Will the rolling mills lead in this change? For them to do so involves the duplication of sections and assortment of rolls, the doubling of the number of changes of rolls, with the resulting loss of time and of the warehouse stocks to be carried. Incidentally, they will recalculate and reprint their tables of the properties of their sections, first in transition form for existing sections and then in metric form for the new sections, supplying also, meanwhile, the existing tables for those recalcitrant engineers who prefer the old and simple way. When it is all done, the new sections will do their

work no better than the old, and we cannot look for enthusiasm in that quarter.

The doubling of stocks to be carried is the minimum involved. During the transition period we will have occasion to put English pulleys on metric shafts, and metric pulleys on English shafts, and we shall therefore require the following pulleys: English bore and rim; metric bore and rim; English bore and metric rim; metric bore and English rim. A pulley manufacturers' warehouse stock now comprises about 10,000 pulleys. The multiplication of this list by four will curb enthusiasm in that quarter.

In pipe fittings the case is equally serious. The new sizes of pipe must be connected with the old, and the most simple fittings—nipples and couplings—would be multiplied by three and the tees and crosses by not less than six. As before, the new pipe and fittings will carry water, steam and gas no better than the old. These illustrations can be extended indefinitely, but I must stop somewhere.

Shall we then conclude that the change is impossible and therefore not to be feared? That would be as shallow, as stupid and as fatal as the worst of the metric conclusions. Let no one forget that, while a complete change is impossible, a partial change is easy—as easy as going down a toboggan slide—and this partial change is exactly the thing that leads to the welter of confusion which I have endeavored to picture. Let no one imagine that in the absence of compulsory law he can use it or not as he sees fit. Once here, we must all deal with it and use it, whether we wish to or not. In this matter no man lives unto himself. Every metric stone thrown into our industrial lake is the center of an expanding area of disturbance. If this paper means anything, it is that a partial change spells total confusion and that every introduction of the system is to be fought as the intrusion of an enemy of our industrial life.

COOPERATIVE COURSES IN COMMERCE AND ADMINISTRATION.

University of Cincinnati.—The college of engineering and commerce at the University of Cincinnati announces the inauguration of a five-year coöperative course in commerce and administration beginning September 22, 1919.

This course is planned to meet a demand on the part of the larger business organizations for men thoroughly trained not only in the commercial side of business enterprises, but in the production side as well. The relationships between production, marketing, accounting, and finance are so close that a knowledge of all of them is essential to work in the higher commercial positions related to large business undertakings. The coöperative course to be inaugurated next fall will include theory and practice in all of these phases of business.

The general plan is the same in detail and operation as in the coöperative course in engineering; that is to say, students will work alternating bi-weekly periods at practical work in business concerns and theoretical work in the university. The practical work during the first years will be in certain carefully selected departments of production, in the shipping departments of large concerns, in the traffic departments of railroads, and in the planning departments of factories. This work will cover a period of about two and one half years, after which the student will be transferred to the commercial side of business for the next two and one half years. In the university, the courses will follow the same general trend. The earlier years will be given to mathematics, fundamental sciences, and to engineering; and the latter years to commercial subjects such as accounting, finance, marketing, business law, management, and so on. As in the coöperative engineering course, students will be paid for their practical work in business concerns just as the engineering students are paid.

The requirements for admission are the same as those shown on page 15 in the announcement of the college of engineering. The rates for tuition and fees are also the same as in the engineering course. In fact, all of the details of operation, cost, and wages are just the same as those announced for the engineering course.

Thus it is intended to prepare students for careers in the commercial world as thoroughly and as broadly as they are trained for work in the various fields of engineering, and to fit them upon graduation to take positions of responsibility in commercial and industrial concerns.

Upon successful completion of the course, students will be given a degree of bachelor of science in commerce.

The night courses in commerce at the university which have been given heretofore will be continued and will be amplified by the addition of fundamental courses in production and management.

Requests for additional information should be addressed to the College of Engineering and Commerce, University of Cincinnati.

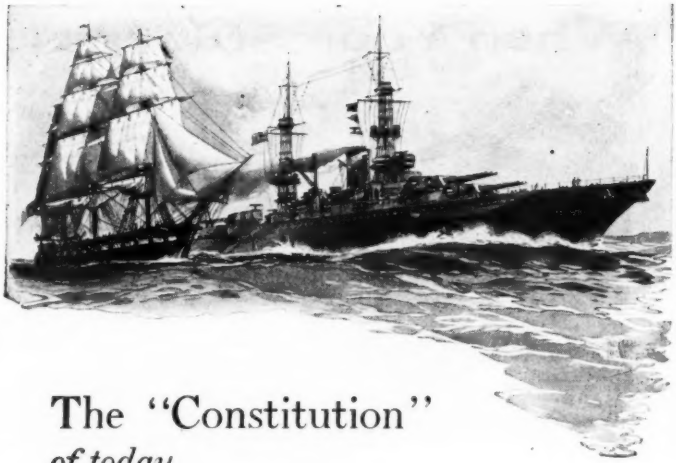
BOOK REVIEW.

Descriptive Geometry. By W. H. MILLER, M.E., Head of Department of General Engineering Drawing, University of Illinois. Fourth edition. v + 176 pages. John Wiley and Sons, Inc., 1918.

This edition is slightly revised to cover some betterments in the typography. Otherwise it is the same as the previous issues which have proven so acceptable.

The subject matter of the text is laid out with the idea in mind that the teaching of students to think logically is of more importance than the technology of the subject. Thus the student who completes this course not only has a complete knowledge of descriptive geometry, but he has developed an ability to apply the principles to other problems which he may meet.

M. I. G.



The "Constitution"
of today
is Electrically propelled

THE good ship "Constitution" was ample in speed and size for its day—but the fighting ship of today is propelled by electric motors, which give it a speed and flexibility of maneuver impossible with any other form of propulsion.

Over 100,000 horse-power is required for a battle cruiser. Electric generating plants on board ship now have greater capacities than most city power plants.

The General Electric Company's generating and propelling equipments are in service not only on the largest types of battle cruisers but in the merchant marine.

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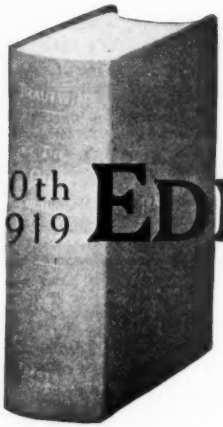

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